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THE
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EPONYMS.

BY SIR D'ARCY POWER, K.B.E., LONDON.

XII. TEALE'S AMPUTATION.

THE death of Mr. Thomas Pridgin Teale last November, at Leeds, reminds us that he was the son of the surgeon who invented the operation of amputation by a long and a short rectangular flap—a method which came into extensive use, and is, even now, more widely used than its merits deserve, for the conditions which it was designed to meet have long since vanished from surgery.

The first description of the operation was published by Messrs. Churchill in a thin octavo volume in the year 1858, in which Mr. Teale says, " In my early days of practice, upwards of thirty years ago, when fresh from the school of Lisfranc, I adopted the transfixion method by two lateral flaps. Charmed by the brilliancy of the operation, I expected it would prove equal to the utmost wishes of the surgeon. In the dissecting room it was certainly admirable, but when practised on the living it did not equal my expectations, and soon gave way to the circular method. At a later period, the example and strong recommendation of others led me to adopt the plan of transfixion with an anterior and a posterior flap. This proceeding was soon left off in favour of the circular incision, which I continued to practise until the middle of the year 1855, when the mode of operating was adopted which it is now my object to describe.

" On reviewing my former practice and experience, if I were called upon to decide between the relative merits of the circular and transfixion methods, preference would be given to the former. My chief reasons for relinquishing these methods of operating are, the imperfect condition of the stump generally resulting from them, and their great mortality."

How great this mortality was is shown in the tables given by Mr. Teale of the results of 640 amputations of the thigh and leg for accident and disease performed in London and provincial hospitals from 1854 to 1857. In London there were 103 deaths in 317 amputations, and in the provinces 102 deaths in 323 cases, or a mortality of nearly one in three. But in addition to the mortality, Mr. Teale points out that the operations in use yielded unsatisfactory stumps. He says " in imputing generally *imperfection of stump* to the circular

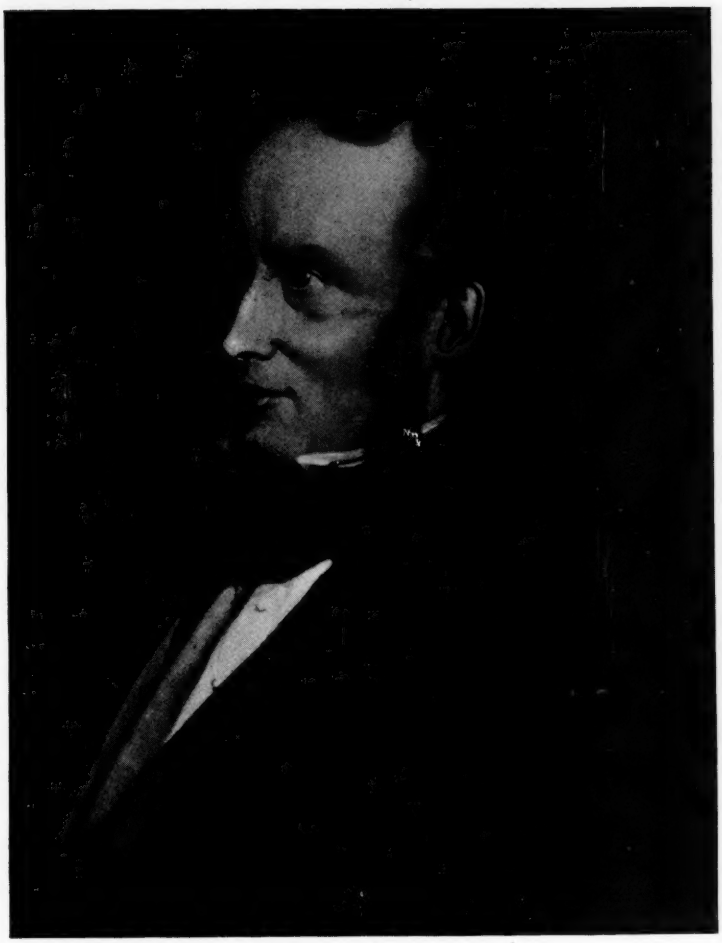
and double-flap transfixion methods I shall perhaps be opposed by most surgeons who have amputated frequently. Each will be ready to say that he is in the habit of making excellent stumps, and indeed such was my own feeling in reference to these operations performed by myself. But when the subject is considered more closely, we may ask ourselves whether a stump is to be regarded perfect merely because it is of seemly form and not offensive to the sight. We ought further to enquire whether it is well adapted to locomotion by being able to bear a considerable portion of the weight of the body on its end. As a general rule it may be stated that the circular and transfixion stumps are not able to bear even the lightest pressure on their extremity.

"Being unwilling to rest this assertion on the personal experience of my colleagues and myself, I must appeal to the evidence which can be furnished by surgical mechanicians who have had extensive experience in the adaptation of artificial limbs." He thereupon quotes Mr. Heather Bigg, who stated that he hardly ever found the cicatrix after amputation of the limbs "*otherwise than adherent* to the sawn end of the bone," and of Mr. Grossmith, who did not "remember any circular or transfixion stumps in which there was a soft, movable mass of tissues over the *sawn end of the bone*, and, as a general rule, he has found the cicatrix adherent to the bone. The cicatrix thus united has proved the most tender part of the stump." Mr. Thomas Eagland, of Leeds, said "that his experience was in perfect accordance with that of Mr. Grossmith and Mr. Bigg, as far as regards the stumps formed by the older methods of circular incision and transfixion."

To procure a more useful stump, therefore, and in the hope of somewhat diminishing the mortality of the operation, Mr. Teale "proposed to amputate by a long and short rectangular flap, the long flap, folding over the end of the bone, being formed of parts generally devoid of large blood-vessels and nerves, whilst these important structures are contained in the short flap.

"The size of the long flap is determined by the circumference of the limb at the place of amputation, its length and its breadth being each equal to half the circumference. The long flap is therefore a perfect square, and is long enough to fall easily over the end of the bone. In selecting the structures for its formation, such parts must be taken as do not contain the larger blood-vessels and nerves. A flap so formed will be for the most part anterior in position as far as regards the general aspect of the body, but superior when the patient is in the recumbent posture, as during the after-treatment. The short flap containing the chief vessels and nerves is in length one fourth of the other. The flaps being formed, the bone sawn, and the arteries tied, the long flap is folded over the end of the bone; each of its free angles is then fixed by suture to the corresponding free angle of the short flap. One or two more sutures complete the transverse line of union of the flaps.

"After the patient has been carried to bed, the stump is laid on a pillow, over which a large sheet of gutta-percha tissue has been spread. *No dressing whatever* is required in the early part of the treatment. A light piece of linen or gauze is thrown loosely over the stump and pillow, and these are protected from the pressure of the bed-clothes by a wire-work guard. To relieve tension the lateral sutures may be removed on the following day, but those of the



Thomas P. Teale

transverse line may be allowed to remain until they are cast off, or appear no longer needed on account of the consolidated union of the parts. When the sutures of the transverse line have lost their hold, if the flaps should gape, a strap or two of adhesive plaster may be applied. Simplicity in the treatment is thus secured, as well as disturbance of the stump avoided.

" To carry out these objects completely, the attendants must be strictly enjoined not to lift the stump from the pillow without the authority of the surgeon. As there are no dressings to be soiled, and therefore to require removal, the stump generally need not be raised from the pillow for many days, or even for two or three weeks. When there is a discharge of matter, the nurse must remove it frequently by a soft sponge from the subjacent gutta-percha, without lifting the stump."

When Mr. Teale wrote, the operation had been performed fifty-six times in Leeds : thirteen times by Mr. Samuel Smith, twenty-seven times by Mr. Teale, fourteen times by Mr. Samuel Hey, once by Mr. C. G. Wheelhouse, and once by Mr. T. Pridgin Teale junior. Seven of the fifty-six patients died. Looking back with our present knowledge, it is clear that so excellent a result was due to the simple dressing and after-treatment rather than to any great merit in the formation of the flaps. Mr. Teale found on following up the cases that nine of the patients were wearing artificial limbs, all of whom were able to pursue their ordinary avocations for the full period of a day's work. " One young man can walk ten miles a day ; and a youth who bore the entire weight on the end of the stump, walked in this condition on one day thirty miles."

Mr. Thomas Pridgin Teale was born at Leeds in 1801, the son of Thomas Teale, who was a successful practitioner in the town. He was educated at the United Borough Hospitals and was admitted a Member of the Royal College of Surgeons in 1823. He then went home again, helped his father in the practice, and was elected Surgeon to the Leeds Public Dispensary in 1824, a position he continued to hold until 1833, when he was appointed surgeon to the Leeds General Infirmary, a post he resigned in 1864, when he was complimented by being elected an Honorary Surgeon.

He soon acquired a large operating practice, in spite of the fact that he had lost the sight of one eye as the result of an explosion whilst he was making chemical experiments as a boy. He excelled in lithotomy, lithotrity, operations for strangulated hernia, for removal of tumours of the jaw, and in 'plastic surgery'. To the end of his life he was active in inquiry and research, and he used to test the new plans of treatment put forward by the various schools in Europe and America. He lectured for twenty-five years in the Leeds School of Medicine, chiefly on anatomy and physiology, and added many pathological preparations to the museum. In 1843 he was elected to the newly established order of Fellows at the Royal College of Surgeons of England, and in 1858 he was selected as a member by the Crown upon the General Medical Council. In 1862 he became a Fellow of the Royal Society, and in 1867 the degree of M.D. was conferred upon him *honoris causa* by Trinity College, Dublin.

Teale had many interests outside his profession. He was one of the earliest and most active members of the Leeds Philosophical and Literary

Society, of which he served as President on two occasions. In 1838 he was elected honorary Curator in Zoology, and he contributed two important and elaborate papers, the one on "The Natural History of the genus *Actinia*", the other on "*Alcyonella Stagnorum*, a Freshwater Zoophyte inhabiting Ponds near Leeds". His last zoological contribution to the Society was in 1839, when he read a paper "On the *Cephalopoda*", but in 1852 and 1853 he contributed valuable geological memoirs, "On the Fossil Fishes of the Yorkshire Coal-field", and "On the Aire Valley and its Organic Remains". His sole relaxation lay in salmon fishing. He died on December 31, 1867, having maintained and even enhanced the surgical reputation of the Leeds School of Medicine founded by Hey and Smith.

The portrait is copied from an engraving kindly lent by Sir Berkeley Moynihan, Bt., K.C.M.G.

INJURIES TO THE KIDNEY AND URETER.

By HAMILTON BAILEY, London.

INTRODUCTION.

Injuries to the kidney, in regard to the collection of cases upon which to base a paper, fall sharply into two groups: (1) *Those in which the injury is mainly, if not entirely, confined to the kidney*; and (2) *Those in which the injured kidney is but one of two or more severe internal injuries.*

Between 1902 and 1923, one hundred and thirty-five cases of injury to the kidney were admitted into the London Hospital; of these, twenty-seven belong to *Group* 2.

Group 2.—Multiple internal injuries in which the injury to the kidney is but an incident have but little bearing upon the clinical side of the subject in hand. Most of the patients in this group were admitted to hospital in a moribund condition, and all died shortly after admission. In the majority the shock was so profound as to preclude all possibility, or even necessity, of making a precise diagnosis, and a ruptured liver, spleen, or intestine, fractured pelvis, and lacerated lung, in addition to a ruptured kidney, was found at necropsy. In four of the 27 cases a laparotomy was performed for a hæmoperitoneum, in one a ruptured liver was packed, and in three a lacerated spleen was extirpated.

In former communications[8, 12, 20] upon this subject it has been customary to discuss and include in the series of cases, "ruptured kidney complicated by ruptured liver, or spleen, etc". Observing that the general condition permitted an exploratory operation in only four instances, and that in each of these a ruptured intraperitoneal viscus alone received attention, it would appear reasonable to state that a ruptured intraperitoneal viscus should not, except in rare instances, be designated as a complication of a ruptured kidney, but rather vice versa.

The present paper is based upon the 108 cases belonging to *Group* 1, admitted to the London Hospital between 1902 and 1923. In addition, cases of injury to the kidney between the years 1893 and 1902 have been collected from the same source and consulted, but not analysed in detail.

STATISTICAL DETAILS.

Relation to Peritoneum.— In all the 108 cases the rupture was extra-peritoneal.

The Side Injured.—The side affected was: left kidney, 50; right kidney, 39; side not stated, 19.

In series that include post-mortem evidence (multiple injuries)[8, 12, 20] the right kidney is most frequently damaged. In the present series the reverse proved to be the case.

Incidence.—Females were much less frequently affected than males: males 99, females 9.

The most important and obvious cause of this very great discrepancy is that males, by reason of their work, are more liable to injury. Contributory factors are the wearing of corsets and the greater renal mobility in females.

Mortality.—Number of cases treated expectantly, 82; number of cases treated by operation, 26. The only death was due to chloroform poisoning.

The gross mortality of these accidents has been reduced considerably during the past thirty years, principally owing to: (1) The prevention of infection (cystitis, pyelonephritis); (2) Operative intervention for the arrest of hæmorrhage in selected cases. The first instance of nephrectomy for a rupture was in 1883. The operation was performed by Henry Rawdon[11] at the Infirmary for Children, Liverpool. The patient died twenty-three days after the operation, of cystitis and pyelonephritis. It was some years after the pioneer work of Rawdon that the limitations of expectant treatment (brilliantly successful as this treatment is in the majority of cases) were realized.

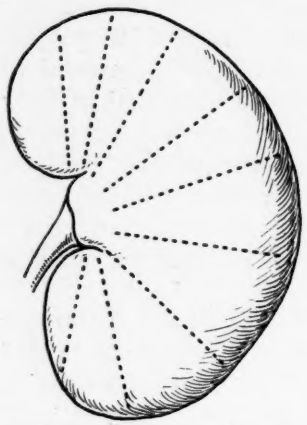


FIG. 332.—Diagram of kidney to show usual lines of rupture.

Analysis of Operations in this Series.—Nephrectomy was performed 21 times; partial nephrectomy once; suture twice; tamponade once; drainage of infected perirenal hæmatoma once; total 26.

Morbid Anatomy.—Rupture usually occurs along a line radiating from the renal pelvis. The line of cleavage follows the direction of the uriniferous tubules (*Fig.* 332), as Keen[9] pointed out.

Although it is stated that the anterior surface of the kidney is the most frequently ruptured, it was found in this series that the posterior surface was equally liable to be the main site of laceration. In 25 consecutive cases requiring exploratory nephrotomy for injury, 6 had the lower pole (*Fig.* 333) and 1 had the upper pole completely severed. The renal pelvis may alone be torn, as occurred in 2 cases in this series. Post-mortem evidence in cases of lacerated kidney showed that the adrenal body is frequently injured. This undoubtedly accounts in a large measure for the profound shock that sometimes accompanies kidney injuries. Very occasionally the renal pedicle is completely torn across. When this is the case, other organs are usually lacerated also.

Anæmic infarction due to rupture of one of the radicles of the renal artery sometimes occurs. The infarct in the lower pole of the specimen illustrated (*Fig.* 334) may have been due to a tear of an aberrant renal vessel, for after the renal pedicle was ligatured and the kidney removed, an artery in the lower part of the wound had to be secured separately. Mr. Girling Ball[24] recently demonstrated that infarction and necrosis in the kidney may follow an operation for division of abnormal renal vessels.

The Nature of the Violence.—It is stated in leading text-books that the usual accident which results in injury to the kidney is a crush (e.g., between buffers). As far as the practice in the East End of London is concerned, this

type of accident is rarely the cause of the injury in question. There is but a single example of a crushing accident in the accepted meaning of the term. This occurred between a bullock and a slaughtering-block.

In five cases only was the blow definitely applied to the anterior belly wall. In over 80 per cent of the cases the violence is stated to have been applied on the posterior or lateral aspect of the trunk.

There is but one case in all the world's literature of a ruptured kidney occurring as a birth accident.[5] Spontaneous[20] rupture in acute parenchymatous nephritis has been reported.

FIG. 333.—Ruptured kidney—run-over accident.

FIG. 334.—Ruptured kidney following a kick from a horse—anæmic infarction of lower pole.

Küster's[11] experimental work on animals and on the cadaver led him to believe that rupture from direct violence was due to an increased intranephric hydraulic pressure at the moment of impact. The same authority came to the conclusion that when the kidney was damaged by indirect violence the injury was caused by an impact of the kidney against the upper lumbar transverse processes or the 12th rib. This work was done by Küster thirty years ago, and apparently his experiments have never been repeated, nor his theories challenged.

Sir Henry Morris[13] believed that a fractured 12th rib in some instances was the direct cause of the laceration.

The type of injury in the majority of cases in this series falls sharply into certain categories, viz :—

1. Falls on the back or side from a raised position to the ground ..	40	
Falls from a height on to feet or buttocks (indirect violence) ..	3	
Falls on the level (in both these cases the kidney was hydronephrotic)	2	
	—	45
2. Kicked by horse (back or side)	17	
'Kicked' or 'kneed' (mostly football accidents)	9	
	—	26
3. Run over		10
4. Glancing blows from passing vehicles		6
5. Hit in back by falling objects (usually when stooping) ..		6
6. External wounds (stabs)		3
7. Other accidents		12
		108

Contrary to expectation in an age of mechanical transport (1902–23), the largest individual incidence was a 'kick from a horse'.

It is of considerable significance that in 6 of the 26 cases operated upon, the ruptured kidney was found to be also diseased. Brief notes of the operative findings in these cases are as follows :—

Case 1.—Deep transverse rupture of the kidney. One large calculus lying free in the perinephric blood-clot, four smaller calculi in kidney substance.

Case 2.—Tear of the renal pelvis. Hydronephrosis. Ureter much thickened.

Case 3.—Tear of renal pelvis 2 inches long. Kidney hydronephrotic.

Case 4.—Hæmorrhage into and around large (? congenital) hydronephrosis. Ureter dilated. Kidney parenchyma very thinned out.

Case 5.—Hæmorrhage into advanced hydronephrotic kidney. Kidney contained one stone.

Case 6.—Deep transverse rupture of kidney, full of cysts. Histological report: congenital cystic kidney.

In two of the above cases the injury was comparatively slight (falls to the ground while walking in the street).

CLINICAL FEATURES.

For purposes of instruction, injuries to the kidney are often divided into two great classes : (1) *Slight*, which embrace those cases that can be treated expectantly ; and (2) *Severe* cases which require operation in order to prevent death from hæmorrhage.

Admittedly this classification is impressive, and serves to emphasize certain valuable points. Nevertheless, at times it is somewhat ambiguous, as the following case illustrates :—

Case 1.—Male, age 18, was kicked in the right loin by a horse.

On Admission.—Pulse 86, temperature 97·8°. There was no sign of external injury or swelling in the loin. Considerable tenderness of right side of abdomen was present, also rigidity of upper right rectus. The urine contained blood. Slight hæmaturia continued for five days. During this time the rigidity persisted, and the patient complained of pain in right side. Pulse remained full and slow. Suddenly, at 1.30 p.m. on the sixth day, there was a torrential hæmaturia. The lad became collapsed. After morphia and posture had improved the general condition, a lacerated kidney was extirpated.

Delayed severe hæmaturia occurred in two other cases on the third and fourth days respectively after accident.

It follows then that if this classification is to be retained, a 'slight' injury should imply one embracing the following stipulations: (1) There are no general signs after an arbitrary period, say one hour, to allow recovery from shock; (2) There are no local signs; (3) The only feature which draws attention to the fact that the kidney has been damaged is a trace of blood in the urine.

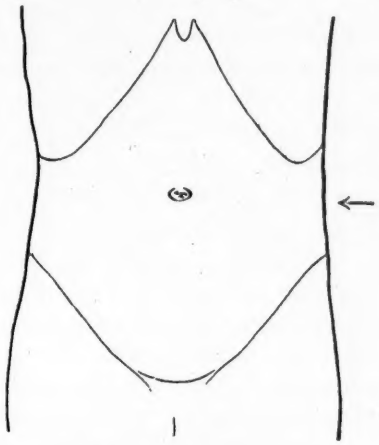


Fig. 335.—Showing flattening of the normal contour on the affected side (indicated by arrow).

On the Local Signs in 'Severe' Cases.—The absence of superficial bruising counts for nothing; it was present in only a small proportion of the cases. The same may be said of the classical 'swelling in the loin' when the posterior aspect of the patient is inspected.

Of greater general utility as an early sign is a flattening of the normal contour on the affected side when viewed from the front, provided the patient is spare (*Fig.* 335).

A dullness of the percussion note lateral to the outer border of the rectus as compared with the opposite side is often a sign of value, whilst rigidity of the anterior abdominal wall on the affected side is constantly present in cases of ruptured kidney.

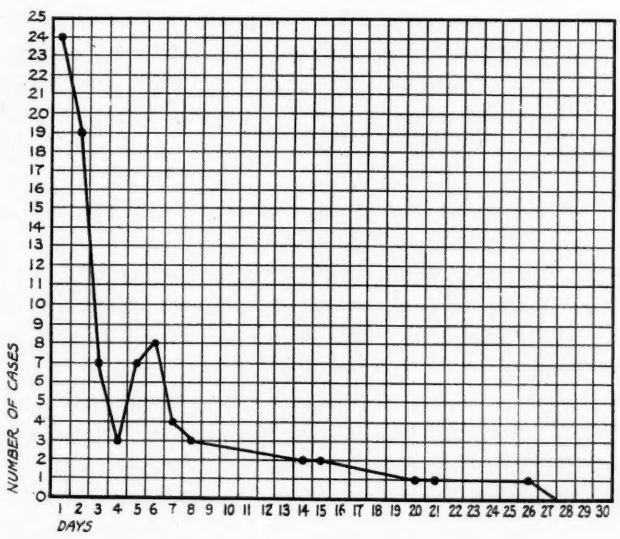


Fig. 336.—Graph showing the duration of hæmaturia in cases treated expectantly.

Hæmaturia.—This cardinal sign of damaged kidney may not make its first appearance until some hours after the accident. In quite a large proportion of cases the urine voided soon after the accident was clear. The second sample, however, showed blood and urine intimately mixed.

Exceptionally the hæmaturia was not noticed for some days; this, however, occurred after slight injuries, and it is highly probable that the blood escaped notice in the earlier stages.

Those cases treated expectantly in which the macroscopical evidence of blood in the urine was recorded have formed the basis of the above graphic representation (*Fig.* 336).

It will thus be seen that, in the vast majority of cases, the hæmaturia ceased by the third day after the accident.

Clot Colic.—Two different clinical conditions are included under this heading :—

1. *Ureteric colic.* This is not very common, and when seen usually occurs within forty-eight hours of the accident. The passage of clots down the ureter give rise to pain radiating from loin to groin.

2. *Bladder colic* is a much more frequent complication. It occurs generally between the third and fifth day. The pain is considerable, and referred to the glans penis.

The passage of clots does not necessarily produce colic. In two cases large quantities of clots were passed without any inconvenience.

Severe Delayed Hæmaturia.—A sudden profuse hæmaturia may occur (usually between the third and fifth day) in a patient who appeared, up to that time, to be progressing favourably. Three such cases, one of which has been cited, occurred in this series. The determining factor is probably some movement on the part of the patient which dislodges a clot into the renal pelvis.

Under the title *hæmaturia tardive*, Tuffier[20] describes the passage of large quantities of dark, altered blood occurring several days after the accident. Yarrow[23] has demonstrated hæmatoporphyrin crystals in the urine of a patient convalescent from a renal injury. In the most recent case of delayed hæmaturia in this series, the large secondary hæmorrhage was heralded by the passage of some 8 oz. of very dark urine.

In 1884, H. A. Reeves,[18] surgeon to the London Hospital, recorded a case of severe delayed hæmaturia in a boy. The secondary hæmorrhage occurred on the tenth day after the accident, and was treated by subcutaneous injections of sclerotic acid. Death resulted, and the necropsy revealed a lacerated right kidney and a traumatic aneurysm of the renal artery. The latter is one of the first instances of this rare condition to be published.

Residual Hæmaturia.—This may be the cause of some anxiety after nephrectomy has been performed for ruptured kidney. In spite of the fact that a damaged kidney has been removed, blood-stained urine continues to be passed. In such instances, one might well wonder whether the remaining kidney is injured also. The explanation is, that urine becomes stained by washing over clots that are present in the bladder. Blood-stained urine continued to be passed for from three to ten days in 20 per cent of those patients in this series in which nephrectomy had been performed. Doubtless residual hæmaturia plays a part—how much it is difficult to estimate—in very many cases of prolonged hæmaturia following renal injuries.

Retention of Urine.—Acute retention occurring a few hours after the accident was present in 8 per cent of the cases. In these cases there was no evidence that the condition was due to blood-clot. Retention of urine occurring soon after the accident is probably reflex in nature.

True clot-retention occurred in a few instances, but in these the retention commenced about the third or fourth day after the accident.

Oliguria, Anuria.—Reflex oliguria is the rule after even a moderately

severe injury to the kidney. Complete anuria occasionally results. In this connection the following case (which is not included in the series) is of interest.

Case 2.—Male, age 24, railway man. Admitted to Liverpool Royal Infirmary, Oct. 28, 1921. Had been crushed between buffers two hours before admission.

On Admission.—There were pain and bruising in the left loin. Pulse was 90, temperature 97°. General abdominal rigidity. Urine normal. After anti-shock treatment had been instituted, general abdominal rigidity still persisted. Frequent vomiting, slight rise in pulse-rate.

Operation.—Laparotomy showed only subserosal hæmatoma in mesentery. Abdomen closed.

Next day the patient passed no urine. The following day he was catheterized, and only 2 oz. of urine secured, which contained altered blood. For four days complete anuria persisted in spite of diuretics. Frequent vomiting. Death. At the necropsy there was shown to be a hæmatoma in the parenchyma of the left kidney, and the capsule was intact. The right kidney and ureter were entirely absent.

Rupture of a horse-shoe kidney which terminated fatally from suppression of urine has been reported.

Meteorism.—In many cases of severe renal injury abdominal distention is seen, and may give rise to difficulty in precise diagnosis. Theoretically, it might be reasonably conjectured that early and obvious signs of a severely damaged kidney would mask an intraperitoneal complication, such as a ruptured intestine, and if this were so, a ruptured kidney might be explored and dealt with effectively via the lumbar route whilst an (additional) intraperitoneal complication was unavoidably overlooked. Between 1893 and 1923 no such case occurred at the London Hospital, from which the comforting conclusion can be drawn that in a given case of severe abdominal injury, if the patient rallies from the shock and the signs are definite enough to indicate that the kidney has been severely damaged, subsequent meteorism does not, as a rule, imply a dual lesion, and the case can continue to be treated expectantly as far as the peritoneum and its contents are concerned.

De Quervain[4] suggested that abdominal distention, following a renal injury, was due to interference with the blood-supply of that portion of the colon overlying the kidney. The records of the London Hospital support this view. Two cases of abdominal injury characterized by hæmaturia and considerable meteorism were explored through a laparotomy wound. In both, bruising of colon, as shown by subserosal punctiform hæmorrhages, was seen.

Urinary Infection.—Cystitis or pyelonephritis following injuries to the kidney is not now the rule. It occurred in only 7 per cent of the cases in this series, and in no case did it prove fatal. In looking over an earlier series (1893–1902) of similar injuries, one is struck with the frequency in which intermittent pyrexia and pyuria followed these accidents. Sir Henry Morris[14] in 1888 found that in 67 deaths resulting from renal injury 27 were due to sepsis. The improvement doubtless has been brought about by the routine employment of urinary antiseptics in these cases.

Perirenal Extravasation of Urine.—In tears of the renal parenchyma, contrary to what might perhaps be expected, perirenal extravasation of urine rarely occurs. Of the two million[1] uriniferous tubules which constitute the renal parenchyma, comparatively few are directly implicated in any individual

tear. Especially is this the case if the tear follows, as it usually does, the long axis* of the tubules. But this alone will not explain the infrequency of urinary extravasation in parenchymal renal injuries. It must be taken for granted that if any part of a uriniferous tubule is divided, the whole mechanism of that individual glomerulus and tubule ceases to function.

Perirenal extravasation of urine occurs principally in: (1) Tears of the renal pelvis; (2) Ruptured ureter (which is most frequently a tear at the pelvo-ureteric junction); (3) Ruptured hydronephrosis.

A medical student, age 24, was admitted to the London Hospital in 1908. The history was that he had been kicked at football in the left loin fourteen months previously in New Zealand. After the accident, hæmaturia persisted for five days. During this time a lump appeared in the left side. This was aspirated and one pint of clear urine withdrawn. After one month in bed he came to England to study. He was quite well until two days before admission. When examined there was a large lump in the left loin. After four days' rest in bed a large quantity of urine was passed and the swelling disappeared. Since 1908 he has played in international football and has served in the Army. He still has periodic attacks of renal colic, which generally occur after a larger amount of fluid than usual has been consumed.

This appears to be a case of rupture at the pelvo-ureteric junction. Cicatricial stenosis at the site of the injury is the cause of the intermittent hydronephrosis.

Perinephric Hæmatoma.—This is frequently met with in cases of renal injuries. The hæmatoma sometimes caused a bulging in the loin, but this was somewhat exceptional; more frequently it tracked retroperitoneally to the iliac fossa. One case of perirenal hæmatoma (complicated with other internal injuries) seen at necropsy, and two cases viewed through a laparotomy wound, were observed to infiltrate and push forward the mesentery. It is stated that the hæmatoma may follow the course of the spermatic vessels, and after a few days ecchymoses appear in the skin of the scrotum, and round about the external abdominal ring. Concerning this phenomenon (which has not been noted in any of the cases of this series), Sir Henry Morris[13] pointed out that most of the cases in which it had been observed were complicated by a fractured pelvis. Not unnaturally, therefore, some scepticism exists as to the relationship of the perirenal hæmatoma and this remote bruising. Secondary infection occurring in these hæmatomata proved to be most exceptional. Of thirteen cases of perirenal hæmatoma large enough to be specially mentioned in the notes, only one became infected; the remainder, all treated expectantly, resolved.

The possibility of these collections of blood being the cause of the perinephric abscess, in the general meaning of the term, is an interesting hypothesis. Twenty consecutive cases of perinephric abscesses were therefore reviewed in the hope of establishing some connection between the two conditions. There appears, however, but little to justify a co-relation. A history of injury was obtainable in only 5 per cent, and if one takes into consideration

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* This should be the best line for incising the kidney in nephrolithotomy—the one least likely to give urinary fistula.

the readiness with which a hospital patient will attribute his condition to an accident, the number of perinephric abscesses which are suppurating hæmatomata must be exceedingly small. Furthermore, perinephric abscesses rarely point in the iliac fossa. Perinephric hæmatomata, as has been shown, frequently do so.

As in hæmatomata of other situations, very occasionally the extravasated blood becomes encysted, and in process of time the cyst wall calcifies. Such a case is published in the *St. Thomas's Hospital Reports*[19] and quoted by Morris. The calcified hæmatoma was removed in the belief that it was an ossifying sarcoma.

MANAGEMENT AND TREATMENT OF RENAL INJURIES.

'Slight' Injuries.—Even when there are no general and local signs, all cases of hæmaturia following an accident should be put to bed and kept there until one week after all macroscopical evidence of blood in the urine has disappeared. A urinary antiseptic is administered to prevent the supervention of infection.

'Severe' Injuries.—If on preliminary examination the case gives rise to the slightest anxiety, the pulse-rate should be recorded hourly. If this measure has been deemed advisable in the first instance, then the frequent pulse-reading should be continued for a longer period than the patient's general condition seems to justify, for, as has been shown, signs of extensive laceration may be considerably delayed.

General Rest.—Once a precise diagnosis has been made, morphia is administered, and repeated as necessary.

Methods of Promoting Local Rest.—

1. *Strapping the affected side* with adhesive plaster is an effective method of ensuring rest, and is recommended by several authorities.[22] Nevertheless its disadvantages are formidable—notably, the local signs are hidden beneath the splint, and increasing rigidity or local swelling cannot be observed.

2. *Rest between sand-bags.* A cloth having been laid across the abdomen, sand-bags are placed on either side of the patient. This effectively prevents moving, and allows examination of the region.

3. *An ice-bag* is a valuable placebo. Methods 2 and 3 can be combined with advantage.

In all cases the urine should be saved and placed in glasses bearing a label indicating the time of voiding. It is then possible to compare one sample of urine with a later specimen, and thus to estimate whether the external bleeding is progressive or not. In comparing two samples—especially in an artificial light—it is often helpful to dip a strip of white blotting-paper into each specimen after stirring. For purposes of comparison, the concentration of blood in the urine is more readily seen in the absorbent paper. The presence of clots in one sample would of course vitiate the result.

I. The Diagnosis was Doubtful, and an Exploratory Laparotomy has been Performed, and a (retroperitoneal) Ruptured Kidney is found :—

Two methods are available for dealing with the kidney: (1) To sew up

the laparotomy wound, turn the patient over, and make a lumbar incision; (2) To remove (or rarely to suture) the kidney via the abdominal route.

There are very great disadvantages in the former method: for instance, the abdominal wound is very hastily closed and hernia may result, as occurred in one case of the series. The abdominal wound must be dressed, the patient turned, the lumbar skin sterilized, towels adjusted, and so on—all of which are time-consuming. Even then it is usually found that the position of the patient leaves much to be desired. Finesse of adjustment cannot be obtained as in the case of a 'set' lumbar operation.

It would appear that in these cases the second method is the one of election. The coils of intestine are packed off carefully. If exposure of the renal area is inadequate, the laparotomy wound should be turned into a Rutherford Morison[3] kidney incision by a transverse incision outwards. The peritoneum is then divided on the outer side of the colon, and the colon and its mesentery are mobilized medially; after blood-clot has been sponged away the renal pedicle is secured and the kidney removed.

The lateral extremity of the transverse wound is used for drainage, which is necessary in many cases.

II. The Diagnosis of Ruptured Kidney has been made:—

Indications for Exploration (via the lumbar route): (1) The immediate hæmorrhage is severe enough to endanger the patient's life; (2) The hourly pulse-reading is steadily rising, especially in spite of morphia; (3) Severe secondary hæmaturia (blood transfusion after the pedicle has been secured is necessary in certain cases); (4) Continued moderate hæmaturia over many days—and consequent anæmia.

In a patient whose condition gives rise to no immediate anxiety, but the hæmaturia persists in spite of general and local rest, or other signs make the exact extent of the injury doubtful, Friedman has suggested pyeloradiography to ascertain the site and severity of the lesion. Whilst, theoretically, this would appear to be a measure not entirely free from danger, in Friedman's hands it has given most illuminating results.

III. The Advisability of Lumbar Exploration has been decided upon:—

The Anæsthetic.—Chloroform should be avoided in these patients. It has been shown that oliguria is the rule, and cases of serious depression of renal function are unable readily to eliminate a poison. The only death in this series following an operation upon an injured kidney was shown at post-mortem to be a case of chloroform poisoning—by jaundice, and fatty degeneration of the liver and remaining kidney.

Determining the Presence of the other Kidney.—While only one individual in 1500 has congenital absence of one kidney, it should be the rule in injuries to the kidney to ascertain the presence of a second organ on the non-affected side. It is rarely permissible to neglect this step. The methods available are: (1) Palpation under anæsthesia—frequently unsatisfactory. (2) Cystoscopy combined with injection of indigo-carmine—time-consuming, for the bladder has usually to be washed out before anything can be seen satisfactorily. This excellent method is not available in urgent cases of

severe hæmorrhage. (3) Deliberately opening the peritoneum in the ventral portion of the lumbar incision, and transabdominal intraperitoneal palpation. The hole in the peritoneum is subsequently sutured.

Indications for Nephrectomy.—(1) The renal pedicle is torn. (2) The kidney is lacerated in several places. (3) There is a tear extending towards the renal pelvis, but the kidney has a short pedicle and cannot be completely delivered; it is impossible to suture a rent which cannot be displayed. (4) There is an extensive rent in the renal pelvis (which cannot be sutured), or the ureter is completely avulsed. (5) The injured kidney is hydronephrotic or otherwise severely diseased.

IV. Every Effort should be made to Save the Damaged Kidney. Conservative Operations upon the Kidney which can be adopted in certain cases :—

Tamponade.—Küster[12] considered this to be the best of all methods. He also taught that it might be used as a temporary measure preparatory to nephrectomy a few days later. Keen has shown that secondary nephrectomy after tamponade carries a high mortality. At the London Hospital in the final decade of the last century this was the method most generally adopted. The perirenal space was stuffed with iodoform gauze. The results were on the whole good. Infection frequently occurred, but most of the patients eventually recovered.

Partial Nephrectomy.—Tuffier[20] showed by his experiments that one-third of the kidney could be resected and the remaining two-thirds continue to function. Partial nephrectomy is especially applicable in those cases in which the lower pole alone is damaged.

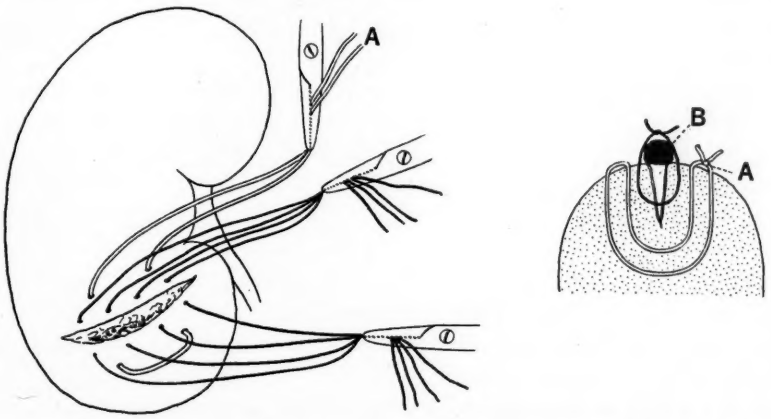

FIG. 337.—Method of suturing a rupture of the kidney. A, Mattress suture, which is tied last; B, Piece of muscle.

Suture.—Of conservative measures this is the one which will be found most generally applicable. Eisendrath[6] recommends that perirenal fat should be used as a buffer under the sutures to prevent tearing out.

Seeing that muscle is always available around a lumbar incision, the following method (*Fig.* 337) of suturing a rent of the parenchyma suggests itself: (1) The passage of a deep mattress suture—a round-bodied curved needle is used—the blunt end of the needle penetrating the renal substance

first. The ends of the suture are left untied and secured with a Spencer Wells. (2) Interrupted sutures are passed deeply, but nearer the edges of the laceration. (3) A piece of muscle is placed over the rupture, and the interrupted sutures are tied over it. Finally, the mattress suture is tied.

The advantages of this method would appear to be that the sutures do not cut out; the muscle being rich in thrombocinase favours clotting; and the rent is plugged with Nature's own material.

Simple Drainage of Perirenal Tissues only.—This should be reserved for two types of renal injury: (1) Perirenal extravasation; (2) Recent injury where a small tear of the renal pelvis is found which cannot, for some reason, be sutured, and the parenchyma is undamaged. A urinary fistula is likely to develop after simple drainage, but spontaneous closure eventually occurs in the majority of instances.

Treatment of Infected Perirenal Hæmatoma.—(Sherren's method.) If on abdominal palpation under the anæsthetic the swelling is found to be invading the iliac fossa (as it usually is), a gridiron incision is made as for appendicectomy. When the peritoneum is reached, it is pushed medially, and the retroperitoneal tissue then opened up with the finger. A tube is passed upwards towards the kidney. The patient is nursed in a sitting position. The infected extravasated blood is drained from its lowest point with minimal disturbance to the kidney, which, by the time the hæmatoma becomes infected, is most probably in a stage of repair.

RUPTURE OF THE URETER.

There is only one instance in the records of the London Hospital during the past twenty years of an undoubted case of intraparietal rupture of the ureter. This was seen at necropsy in association with other internal injuries. The ureter was avulsed from the renal pelvis.

From the clinical standpoint, a ruptured renal pelvis and a lesion of the ureter are indistinguishable (*see* PERIRENAL EXTRAVASATION OF URINE, p. 615). Indeed, even when displayed to the light of day, a tear of the pelvo-ureteric junction is just as much a rupture of the renal pelvis as a lesion of the ureter. A perusal of the literature convinces one that intraparietal rupture of the ureter is an exceedingly rare accident. Certain of the reported cases are by no means convincing. In indisputable instances the lesion has nearly always been found near the junction with the renal pelvis. An exception to this rule was Dumitresco's case in which the lower third of the ureter was lacerated by a fragment of a fractured pelvis.

Nash, during the course of an operation for perirenal extravasation of urine, saw a hole in the mid-ureter discharging jets of urine. He assumed that the rent was due to an injury, although the patient (an adult male) denied an accident of any kind. This interesting condition permits of another explanation, viz., ulceration around a ureteric calculus, as occurred in Raymond Johnson's case. There is no doubt that during the past fifty years pelvic operations* (notably hysterectomy) have accounted for the vast majority of ureteric injuries.

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* Preliminary passage of ureteric catheters would minimize this accident.

CONCLUSIONS.

1. Of all the internal catastrophes, a ruptured kidney treated under modern conditions offers the best prospect of a complete recovery.

2. In those unfortunates with a single kidney, a severe injury of that organ is probably always fatal.

3. The low mortality of renal injuries in general is very largely due to a provision of nature whereby the metanephros was bilaterally represented.

4. Operative intervention for the arrest of hæmorrhage which would otherwise rapidly prove fatal, an appreciation of those signs which herald the failure of expectant treatment, and the prevention of infection, have reduced the mortality to vanishing point.

5. If two or more of the viscera are severely injured, the prognosis is almost as grave as it was fifty years ago. Progress in these cases is impossible until more effective measures of combating shock have been devised.

I beg to record my thanks to the surgeons of the London Hospital in general, and to my chiefs in particular, for many favours.

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INTRAMEDULLARY CAPILLARY ANGEIOMA OF THE SHAFT OF THE HUMERUS, LEADING TO SPONTANEOUS FRACTURE: TREATED BY LOCAL RESECTION AND BONE-GRAFTING.

By SIR HAMILTON BALLANCE, Norwich.

With a Histological Report by Professor S. G. SHATTOCK, London.

In November, 1913, I was asked by Dr. C. H. W. Page, of North Walsham, to see a farmer, age 37, who gave the following history:—

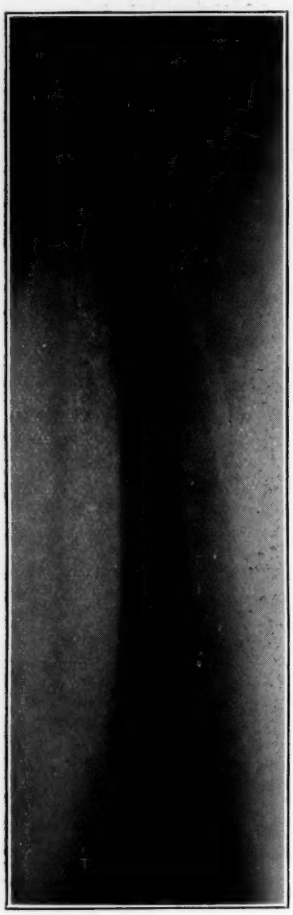

Fig. 338.—Skiagram of patient taken two days before spontaneous fracture.

When he was 13 years of age his left elbow was crushed between buffers, and since that time he had never been able fully to straighten the joint; but with this exception the limb completely recovered. About a year before I first saw him, he began to have pain in the upper part of the left arm; this pain increased and the arm gradually wasted and became weaker.

The patient was a big, muscular man, and, with the exception of the trouble in the arm, enjoyed good health. The most tender spot was at the upper and inner part of the arm, at the lower end of the insertion of the pectoralis major, where a distinct ridge could be felt; the pain started from this spot and passed down the limb and along the back of the forearm to the fingers. A jerk of the limb, such as might occur when the patient was driving, would cause a sudden pain to dart all along the arm and forearm. There was tenderness along the musculospiral nerve in the lower half of the arm, but there was no anæsthesia. There was wasting of the supra- and infraspinatus, the deltoid, the triceps, and the pectoral muscles, and some general wasting of the forearm; all these muscles, however, still reacted to faradism. The power to abduct the shoulder and to extend the elbow was much diminished; flexor power of the elbow was much greater than extensor. There was not much wasting of the thenar and hypothenar eminences and the grip was fair; the elbow-joint could not be extended beyond 140°.

On Nov. 24, the patient was admitted to the Norfolk and Norwich

Hospital and radiographed (*Fig.* 338). The plate shows that for a distance of about three inches absorption of practically the whole of the compact tissue of the shaft of the humerus had taken place, the centre of the thinned portion being rather above the middle of the bone. On Nov. 26, the patient put his arm behind his back, and, although the movement was not a forced one, the humerus suddenly snapped through the weakened portion.

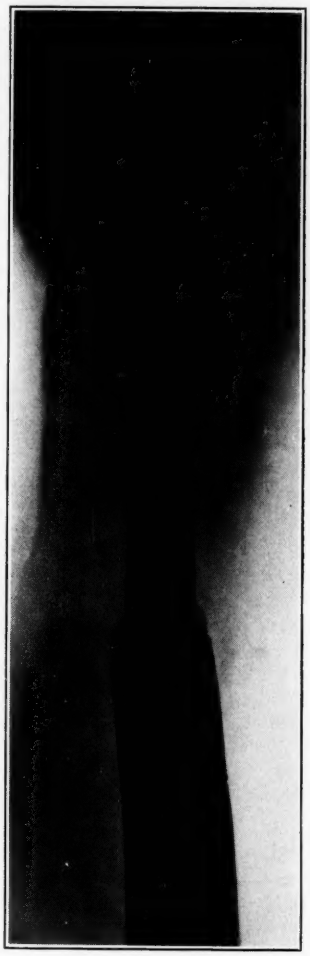

FIG. 339.—Skiagram 2½ weeks after operation, showing fibular graft in position, fixed by screws.

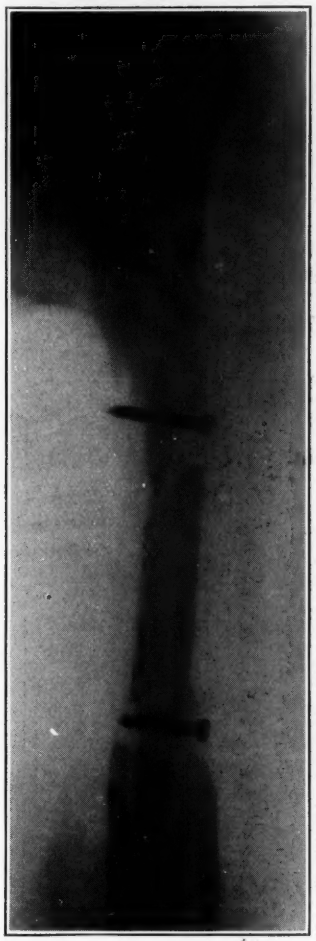

FIG. 340.—Three and a half months after operation. Upper end of graft has come away from humerus, and ends of humerus, as well as graft, are becoming absorbed.

OPERATION.—On Dec. 5, the fracture was exposed by a long incision on the outer side of the arm. The medulla of the fractured ends was noticed to be much redder than usual, and the outer surface of the thinned portion of bone pitted and irregular. Bone was removed from the upper and lower fragments until the cut medullary surfaces appeared of a normal colour. An incision was made over the upper part of the left fibula, and four inches of the shaft was removed with its periosteum. The medullary cavities in the cut

ends of the humerus were too small to receive the extremities of the fibular graft, so these were narrowed by sawing and were then forced into the ends of the humerus, into which they fitted fairly firmly (*Fig.* 339); but to keep the graft securely in position, screws were inserted through the ends of the humerus and of the graft. The wounds healed by first intention, and the

FIG. 341.—Seven months after operation. The absorption has rapidly progressed.

FIG. 342.—Skiagram 8¼ years after operation. Ends of graft have united with humerus, but the graft, greatly diminished in size, has fractured at the screw holes. Upper screw has become eroded near its middle.

patient returned home with an internal rectangular splint on the limb and a poroplastic shoulder cap.

Three and a half months later a radiograph of the patient was again taken (*Fig.* 340), when it was noticed that the upper end of the graft had

come away from the humerus, that both ends of the latter were being absorbed, and that the graft was becoming irregular in outline.

Another skiagram seven months after the operation (*Fig.* 341) showed that the process of absorption in the ends of the humerus and in the graft had still further progressed. The war here intervened and the patient was not seen until some time after the armistice.

In March, 1922, eight and a quarter years after the operation, the arm was once more X-rayed (*Fig.* 342). The graft had joined to the ends of the humerus, but had itself undergone extreme atrophy and had fractured at the points where the screws passed through it.

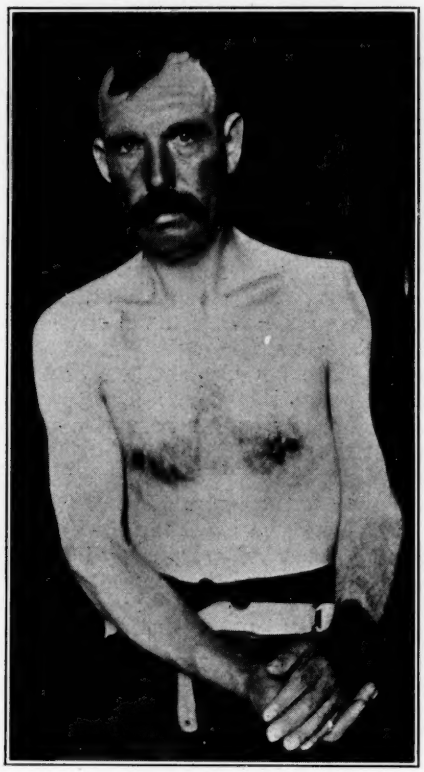

FIG. 343.—Front view, showing atrophy of muscles of shoulder and arm.

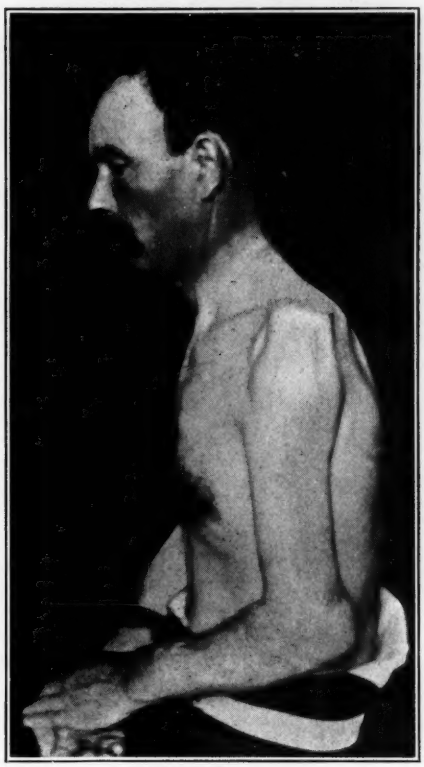

FIG. 344.—Side view.

The patient is now in the position of a man suffering from an ununited fracture of the humerus. He wears a leather case round the arm to give rigidity to that portion of the limb, and by means of this support the forearm and the hand are quite useful to him. The photographs (*Figs.* 343 and 344) show the present condition of extreme atrophy of the muscles of the shoulder and arm.

Fig. 345 shows the condition, five months after operation, of the left leg, from which the fibular graft was taken. A recent skiagram shows much the same condition, and there has been no further progress made in the attempt

by Nature to bridge the gap in the fibula. The irregularity at the upper end of the lower fragment of the fibula is due to the fact that portions of bone, sawn off the ends of the graft to make them fit into the medullary cavity of the humerus, were replaced in the lower part of the wound in the leg. Skiagrams of the right arm and right leg show the bones in these limbs to be quite normal in appearance.

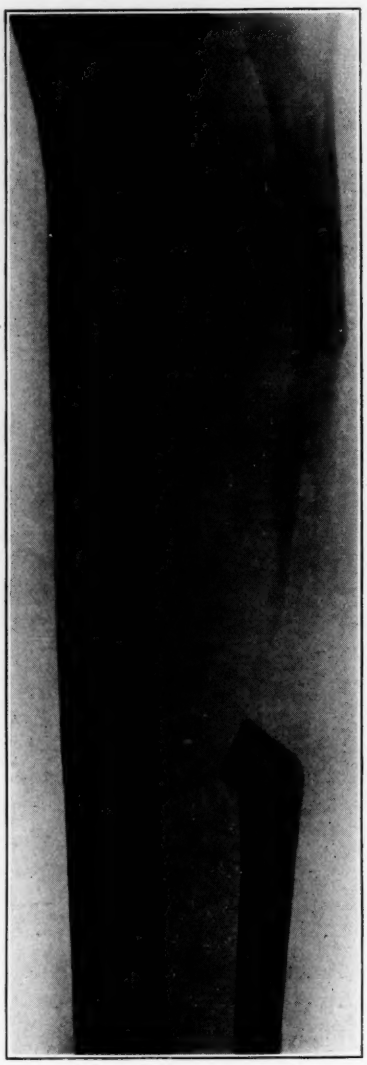

FIG. 345.—Condition of left leg five months after the fibular graft was removed.

HISTOLOGICAL REPORT BY PROFESSOR S. G. SHATTOCK, F.R.S.

As studied in transverse sections of the shaft, the medulla is completely replaced by a capillary angeioma, the vessels of which are abnormally large and are all distended with blood. The capillaries have a simple, flat-celled, endothelial wall. The intervals between are occupied with normal connective tissue in which groups of fat cells are included ; the only other elements present are inconsiderable and ill-defined collections of lymphocytes, distributed in the intervascular connective tissue (*Fig.* 346).

The wall of the shaft immediately around the growth is undergoing rarefaction, the capillaries with their associated connective tissue and scattered lymphocytes having made considerable gaps in the bone by the enlargement of the original spaces. The bone, where not destroyed, is of perfectly normal compact structure, well laminated, and furnished with normal corpuscles in normal numbers.

In certain of the capillaries the red cells have subsided before the coagulation of the blood has taken place after the excision, the coagulum being in consequence wholly or partly homogeneous, vacuolated and it may be dentate at the margin. It may be added that there is not the slightest indication of the neoplasm being sarcomatous.

Professor Shattock adds, " There is no such specimen in the R.C.S. Museum ; I have never myself seen such a thing, nor heard of any such having been observed in this country ".

REMARKS.

The extreme rarity of this case is one of the reasons for putting it on record. In spite of much consultation about it with surgical friends of mine, the true nature of the trouble was only revealed when Professor Shattock's aid was sought, and I am deeply indebted to him for the interest shown and help given, and for the description he has written of the microscopical findings.

To Mr. Lawford Knaggs also I desire to express my thanks for much useful advice and for the references to the literature of the subject.

The blood tumours of bone described by Roughton and others are almost all examples of sarcomata of bone into which hæmorrhage has occurred, and in these cases an important clinical sign has always been observed, namely, expansion of the bone affected. Others, however, have been recorded by some of the older writers in which the development of new vessels in the part of the bone affected has been a marked feature, and in which treatment that

FIG. 346.—Transverse section of thinned portion of shaft of humerus, showing the plexus of dilated capillaries supported by connective tissue in which lie a few fat cells. In the lower part of the section are a normal arteriole and a group of lymphocytes. ($\frac{2}{3}$ obj.)

would have been quite inadequate if the tumour had been malignant has resulted in a cure.

The atrophy of the graft was very disappointing, and this may be due, as Mr. Lawford Knaggs suggests, to its failure for so long a period to unite

with the ends of the humerus; but if the last skiagram of the arm be examined (*Fig.* 342), it will be seen that the ends of the graft, although very much thinned, did eventually fuse with the humerus, and that fractures have occurred at the places where the screws passed through the graft. Some surgeons are much opposed to any fixation of a bone-graft by mechanical means to the bone to which it is expected to unite. It is not my experience that such fixation hinders the bony union desired later.

The question arises as to the best treatment of this patient in his present condition. Supposing a second attempt at grafting were made, including free removal of the ends of the humerus on each side of the atrophied first graft, is it to be expected that a second graft would meet with the same fate as the first? I do not think that this should necessarily occur, but for the present the patient prefers to continue as he is.

It may be mentioned that the man does not seem to suffer any disability from the removal of a good many inches of one fibula, although the gap between the ends has not been bridged by bone.

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AN EXTENSIVE MULTILOCULAR CYSTIC EPITHELIAL TUMOUR OF THE JAW.

By C. A. MOORE, G. HADFIELD, and L. E. CLAREMONT, Bristol.

Cases of multilocular cystic epithelial tumour of the jaw, or epithelial odontome, although rare in the experience of an individual surgeon, have been described for a century or more. For their pathological elucidation we are indebted mainly to Bland-Sutton, Eve, Malassez, Tomes, and others. They possess a triple interest—to the surgeon, the pathologist, and the dental surgeon.

To the surgeon, who has to deal with the question of operative removal, the point arises as to how far they are to be regarded as malignant, and how radical his proposed operation should be. In earlier days they were regarded as definitely malignant, and operations for their removal were extensive and mutilating. Later, the trend of pathological opinion was in favour of their comparative benignity. More recently again, Bland-Sutton has pointed out their close relation, in microscopic character and clinical behaviour, to carcinomata. They are to be regarded at any rate with considerable suspicion. While most pathologists follow Malassez in thinking that they arise in remnants of the enamel-organ, there are others who would label them as endotheliomata, or even epitheliomata, arising in the gum. An excellent summary of the present position was furnished by the report of the committee appointed by the British Dental Association in 1914.

Finally, to the dental surgeon, the problem presents itself of providing some artificial substitute for the jaw. If it cannot be expected to be of much service from a masticatory point of view, it will, at any rate, help to overcome the grave deformity resulting from the surgeon's unaided efforts.

CLINICAL HISTORY.

The patient, a man of 40, was referred for surgical treatment by Mr. W. Holder Shipway, of Chepstow, from whom he had sought dental advice owing to repeated attacks of inflammatory swelling and pain in the enlarged jaw.

The patient stated that he first noticed a swelling inside the mouth, on the left side, twenty years before. For this, a minor operation was performed at Newport. He had no further trouble until six years before coming under notice, when the jaw began to swell again, and this had continued steadily ever since. The teeth had been extracted, or had fallen out, at intervals, and he is now entirely edentulous. The attacks of inflammatory swelling, mentioned above, had come on every few months during this time.

The appearance presented by the jaw is well shown in *Fig.* 347, and in *Figs.* 348, 349. The greater part of the mandible was expanded by an

irregular nodular swelling, most marked on the right side, and gradually tailing off towards the left, where it ceased just in front of the angle. The nodular projections, by their appearance, suggested cysts, while, in the case of the larger ones, the bone was so much thinned that elasticity on pressure, but no 'egg-shell' crackling, was readily felt. No teeth remained in either jaw, so that intrabuccal sepsis was slight.

FIG. 347.—Fibrocystic lower jaw. The upper figure shows the jaw as removed. (A) Mucous membrane of floor of mouth. The lower figure shows the upper half of the jaw in section. (B) Muscle. (C) Periosteum.

The affected portion of the jaw was removed through an incision below it, without serious difficulty or shock, the operation being immensely facilitated by skilful intratracheal anæsthesia. The jaw was divided on the right side just below the notch, only a very narrow bridge of bone remaining to connect the condyle with the coronoid process. On the left side, the line of section passed just in front of the ascending ramus. No attempt was made at any temporary replacement of the jaw by an artificial substitute.

No shock followed, and local sepsis was remarkably slight. By the end of a fortnight all sepsis had subsided and rapid healing had taken place. The

field of operation was occupied by a dense mass of scar-tissue, the contraction of which led to an unsightly hollow in the chin.

At this stage the patient was kindly seen by Sir Frank Colyer, who advised the insertion of an epithelial inlay, according to the method which proved

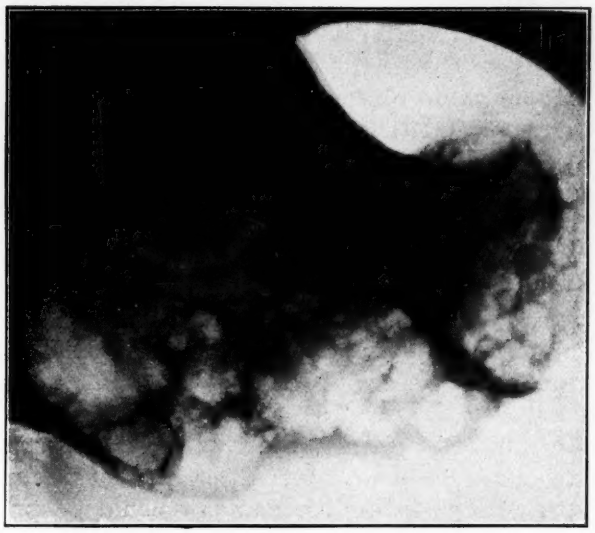

FIG. 348.—X-ray appearance of tumour before removal.

so successful at the Queen's Hospital, Sidcup, and of which details have been published by Kilner and Jackson.[1]

This suggestion was acted upon, three weeks after the first operation. The scar-tissue under the tongue was freely dissected away and the chin set

FIG. 349.—Tumour *in situ*.

free, leaving a large cavity in the floor of the mouth. An impression of this cavity was taken in dental wax and covered with Thiersch grafts. The wax

cast was fixed in place by means of a splint which exerted the necessary pressure to keep the impression, with its covering of grafts, firmly in contact with the raw area in the floor of the mouth. Once more, grateful acknowledgement has to be made of the great help derived from intratracheal anæsthesia. The latter point was amply demonstrated when, at the close of the operation, the intratracheal catheter was removed. The large mass of dental wax in the floor of the mouth, and the firm pressure exerted by the splint, together with the fact that the tongue had again necessarily been set free from its attachments, so obstructed the breathing that tracheotomy was required before the patient left the table. The tube was removed next day, and no further trouble with the respiration occurred.

In the Sidcup method of intrabuccal grafting, it is advised that the grafts be left undisturbed for ten days, and it was intended that this should be done here. At the end of exactly a week, however, the splint let the wax slip and become displaced. It was decided, as the lesser evil, to remove the wax rather than make an attempt to manœuvre it back into place with consequent risk to the vitality of the grafts. This course proved to be justified by the fact that the grafts had taken most completely, not a trace of raw surface remaining. To one whose first experience this was of this method of intrabuccal grafting, the result was as surprising as it was gratifying. After the raw area was covered, practically no further contraction took place, and the work of fitting the new jaw could be proceeded with.

Looking back on the case, we are agreed that it would probably have made things easier if some sort of a temporary substitute for the jaw had been inserted at the first operation, before any contraction of the scar took place.

PATHOLOGICAL REPORT ON THE TUMOUR.

By G. HADFIELD.

Naked-eye Appearance.—The specimen consists of the whole of the body and the lower part of the right ramus of the lower jaw, including the angle on the right side ; on the left side the saw-cut made in removing the specimen passes just in front of the angle. The jaw is edentulous, grossly deformed, and considerably distended by diffuse tumour-growth, which is located within the alveolar borders, except where it has absorbed and pierced them, when it presents on the surface at several points as large low bosses, where it has either pushed the surrounding soft tissues in front of it and lies encapsulated by them, or is still enclosed in a thin parchment-like capsule of bone.

The amount of growth lying between the alveolar borders is so great that the thickness of the jaw is three to four times the normal.

The largest mass of growth lies in the position normally occupied by the incisor and canine teeth, and is covered by intact, smooth, thickened mucous membrane which is stretched over it. Its chief directions of growth have been upward and forward, pushing up and stretching the edentulous gum, and absorbing the external and anterior surface of the bone on each side of the mental prominence. A fairly thick layer of bone still covers it on its lower and posterior surface. Another large mass of growth, continuous with the above, has almost entirely replaced the angle of the jaw on the right side,

whilst between these larger masses several smaller ones have absorbed the bone over smaller areas and project as smaller-sized bosses.

The growth is continuous between the individual masses, and even where it has not absorbed the alveolar borders it has everywhere considerably separated them. A moderate amount of bone still remains on the left side, where the deformity is much less.

On making a horizontal section through the specimen, the diffuse infiltration and unequal distention of the alveolar borders by the tumour are very obvious.

For the most part the tumour tissue is firm, solid, and opaque; is white in colour; looks homogeneous, and resembles sarcomatous tissue; but in the centre of several of the larger masses of growth there are irregularly-circular, smooth-walled cystic cavities from ½ to 2 cm. in diameter, filled by clear, mucinous fluid, or opaque, gummy, yellowish material. In addition to these cysts, some of the solid opaque parts of the tumour show in their centres areas of the same average size as the cysts, where the tissue is translucent and gelatinous-looking and apparently in the precystic stage.

FIG. 350.—Two tubules showing stellate cell reticulum, and columnar cells lining them externally. The tubule as a whole closely resembles a developing enamel-organ.

Microscopic Characters.—The growth consists of many solid branching tubules, flattened from side to side by mutual pressure, and varying considerably in size. They lie in a scanty fibrous matrix, which is almost acellular. Most of the tubules are equally bifurcated; some show three or four equal-sized branches, but they do not appear to anastomose. Each tubule is covered on its external surface by a single compact layer of columnar epithelial cells, which have large, bluntly-spindle-shaped, vesicular nuclei.

The contents of the tubules vary. In all of them the outer part is filled by small stellate cells with rather deeply-staining round or ovoid nuclei; these cells have a scanty cytoplasm, which is continued into four to eight fine processes. The processes of neighbouring cells are fused, and give the tissue a characteristically reticulated appearance. Some tubules contain no other types of cell, and in these the reticulated cells are closely packed and small, and their processes numerous. The majority of tubules, however, contain masses of squamous epithelium, arranged roughly as in the 'cell nests' of squamous-celled carcinoma. These cell masses have applied to their outer surface several layers of flattened reticulated cells; they all show a considerable degree of 'keratinization', loss of nuclear staining, and hyaline transformation. Where these masses are large, the tubule shows microscopic cyst-formation, and in a moderate number of tubules this has progressed to complete transformation

of the cellular contents into a series of discrete simple cysts with smooth acellular walls. The matrix is composed of well-developed fibrous tissue.

The tumour has all the characters of an epithelial odontome (adamantinoma), generally regarded as being derived from the parodontal epithelial débris. This latter tissue is found normally as cellular masses, or primitive tubules, deep in the tissue of the gum, and is derived from invaginations of the gingival epithelium which go to form the enamel-organ; it appears to be concerned with many inflammatory and neoplastic processes which take place in connection with the teeth.

The tumour described shows a small amount only of squamous epithelium, and histologically resembles an adenocarcinoma very closely. The columnar cells lining the tubules represent the enameloblasts of the primitive enamel organ, whilst the stellate cells of the central part of the tubules closely resemble its normal stellate reticulum (*Fig.* 350).

Bland-Sutton, in his book on *Tumours* (1922), remarks that "a careful re-examination of a few of the specimens described as multilocular cystic epithelial tumours of the jaws, and a study of the description of others, especially those occurring in individuals past middle life, indicate that many of these tumours are carcinomas. This view of the matter is confirmed by the fact that some of these cystic tumours of the jaw supposed to arise in belated rudiments, or vestiges, of the enamel-organs, recur after removal. Moreover, these tumours occur in individuals at or after mid-life, whereas, if they arise in epithelial vestiges of the enamel-organ, they ought, theoretically, to be met with in the young: this is not the case".

THE DENTAL ASPECT.

By L. E. CLAREMONT.

At my initial examination of the case, I assumed that it would be possible to replace the portion of the jaw that the surgeon proposed removing, by a hollow box of vulcanite carrying teeth, and attached by springs to an ordinary full upper plate. Having never had occasion to design so large a restoration, I did not take into account the contraction of the soft tissues that would take place immediately after the removal of the tumour.

Four days after the first operation I took a plaster impression of the floor of the mouth. Great difficulty was experienced in obtaining a good impression of the upper jaw, partly owing to the extreme tenderness of the stumps of the vertical rami, but more particularly to the fact that these stumps were pulled inwards towards the middle line by the unopposed pterygoid muscles. Plaster was found to be impossible in the upper jaw. A temporary apparatus was made in vulcanite without any teeth on it, the lower solid vulcanite block being attached to an edentulous upper vulcanite plate by a locking bolt on each side. When in place in the mouth with the bolts locked, the mouth was kept fixed in the half-open position. At the time, I felt that a temporary apparatus of this nature would keep the soft parts well moulded during the process of healing.

In a very short time, it was obvious that the large amount of cicatricial tissue forming in the floor of the mouth under the tongue was steadily drawing

the lower lip and soft tissues of the chin inwards. I asked Mr. Shipway, L.D.S., the patient's private dentist, to come up to the hospital and consult with me as to the best means of combating this difficulty. We decided to ask Sir Frank Colyer to advise as to further treatment. He very kindly came down from London, and suggested to the surgeon that the only way to stop this contraction was to operate again, remove the cicatricial tissue, and line the floor of the mouth with epithelium. Sir Frank Colyer laid great stress on the fact that the apparatus eventually designed should be as heavy as possible, being preferably made of metal.

The first difficulty was the question of some retention apparatus to hold the 'epithelial inlay' in position until union had occurred. The floor of the mouth anterior to the tongue was filled with Stent's composition, and carefully moulded as far as possible to the original contour of the chin. This, when hard, was held in position while a composition impression was taken of the lower part of the face. A model of this facial impression was cast, and a metal splint, made of aluminium, struck up to fit the model. Two processes of metal were carried up over the lower lip and bent round so as to hold a lump of Stent's composition material firmly in the floor of the mouth.

On March 9, 1923, the first operation was done, and on March 28 the cicatricial tissue was freely cut away, composition being carefully moulded to the floor of the mouth, and firmly fixed to the 'processes' coming off the chin splint. The splint and the attached composition were removed from the mouth, and the Thiersch grafts carefully laid on the under surface of the composition. The whole appliance was then dropped into position, a four-tail bandage being attached to the splint, for which slots had previously been cut, and fixed round the head in the usual manner. When the apparatus was finally in position with the mouth firmly held by the splint in the half-open position, a tracheotomy was found to be necessary, as the mass of composition in the floor of the mouth was holding the tongue back and so impeding respiration.

On April 5, eight days later, the apparatus worked loose and had to be hurriedly removed. I may say that during this time the patient was very helpful in keeping as still as possible, despite considerable discomfort from uncontrollable salivation, etc. The skin-grafts were found to have adhered very well to the floor of the mouth.

On April 7 I took impressions in plaster-of-Paris, and designed, with the help of Mr. Wright, my mechanic, an appliance for the lower jaw, consisting of Weston's fusible metal. The metal was cast round six front teeth, and a slot running backwards from the region of the second premolar was cut on each side. A Victoria metal lining was soldered into these slots, and the usual bolts and swivels were soldered into the appliance anterior to the slots, so that the springs when attached would work and lie in the grooves. An ordinary upper vulcanite plate was made carrying six front teeth, with vulcanite blocks in the molar region. Slots similar to those cut in the lower were made in the vulcanite blocks, and lined with Victoria metal. Bolts and swivels were attached in the usual manner in front of the slots. This special arrangement for the springs to work in the slots or grooves was necessary, owing to the previously mentioned difficulty regarding the dragging inwards

of the stumps of the ascending rami. Springs fitted in the ordinary way would have jammed against these stumps and interfered with all movement.

When the appliance was ready to put in the mouth, I found to my disappointment that shrinkage had again taken place, though not to such a considerable degree as occurred after the original operation. The lower appliance was too large, and had to be remodelled to a new impression. In order to avoid this accident occurring again, I had a metal base, without teeth or grooves, immediately cast to the new impression, and arranged for the patient to wear it as long as possible each day. The completed apparatus was finally put in the mouth on April 20.

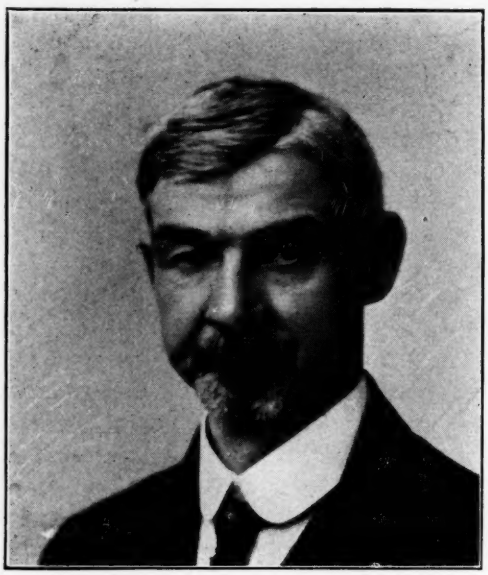

FIG. 351.—Portrait of patient ten months after plastic operation.

I found that not only did the wearing of the appliance stop all further shrinkage, but it became possible, from time to time, gradually to increase the size of the trough in the floor of the mouth by additions of Stent's composition to the outer surface of the appliance. These composition additions were finally replaced by an addition of Weston's fusible metal to the original appliance.

The patient left the hospital on June 7, having grown a beard (*Fig.* 351). His speech and appearance were fairly good; his chief difficulties were masticating and somewhat uncontrollable salivation.

From the dental point of view, I wish to express my thanks first to Sir Frank Colyer for his interest in the case and his invaluable suggestions. Secondly, I feel very much indebted to my mechanic for his skilful work and help in designing a suitable apparatus for a very rare type of case.

The patient originally saw Mr. Shipway regarding the increasing size of his lower jaw, who sent him in to the hospital for advice and treatment. Mr. Shipway followed up the case with me, and is now keeping a periodical watch on the patient.

REFERENCE.

[1] KILNER and JACKSON, *Brit. Jour. Surg.*, 1921, July, 148.

VISITS TO SURGICAL CLINICS AT HOME AND ABROAD.

SOME OF THE SURGICAL CLINICS OF STOCKHOLM.

(SEPTEMBER 22–26, 1923.)

WE first visited the Clinic of Professor Gôsta Forssell and his colleagues at the Radium Institute. This is a hospital of thirty-two beds with a very complete out-patient department and facilities for treating patients with radium and X rays. It was founded by the Cancer Society of Sweden in 1917, and is now recognized by the Government, which pays the travelling expenses of the patients, who thus have no excuse for not coming as often as is necessary, not only for treatment, but also that their after-progress may be watched. There were 832 in-patients during the last year, and 1533 treatments with radium were carried out; the clinic possesses 1353 mgrm. of radium. There are five sets of apparatus for deep X-ray treatment; 6200 'deep treatments' were given last year. There are two sets of diathermy apparatus. The hospital is the only one of its kind in Sweden, and draws its patients from the whole country. Some operable cases of cancer are treated, but only those in which ample experience has shown that the results are as good as, or better than, those which follow ordinary surgical removal. Among such cases are those of cancer of the face or skin elsewhere, the neck of the uterus, and external sarcomas. In all other conditions only inoperable cases are dealt with, so that the latter form the vast majority. Diathermy is being used more and more, and last year 155 operations by this method were performed. Very often electric coagulation, radium, and X-ray therapy are used in conjunction. The diagnosis of all cases is determined by removal of a portion of the growth and microscopical examination.

The wards were visited and a series of cases demonstrated. They were frankly discussed, and some were extremely interesting. Those worthy of special mention were: (1) Sarcoma of the nasopharynx, inoperable in 1921, now apparently well after treatment with radium and X rays; (2) Three cases of malignant disease of the thyroid with apparent cures—one a case of cancer, the other two of sarcoma. The case of cancer of the thyroid was in a woman, age 45, who had been operated on in January, 1921, as it was then thought to be a case of simple goitre. As the growth proved malignant, the operation had to be abandoned. X-ray treatment was given in February and April, 1921, with very little benefit. In May and June deep X-ray therapy was used with some benefit, but the symptoms of myxœdema gradually developed. This was treated with thyroid extract, and the X-ray therapy was continued. By November there were no signs of malignant disease, and since that time she has progressively improved. The myxœdema

has been treated successfully by the administration of 3 cgrm. of thyroid extract daily, and at the time of our visit the patient was apparently quite well.

The two cases of sarcoma of the thyroid which were shown were both women over forty years of age. Each had been treated by X rays. One had been free for five years from any symptoms of sarcoma, but had myxœdema, which was being treated successfully with thyroid extract. The other had been free for eleven years from any symptoms of sarcoma, and no symptoms of myxœdema had developed. Great stress was laid on the fact that the larynx must be protected adequately when radium treatment is carried out on the thyroid gland. It was stated that 13 cases had been reported from Germany in which the laryngeal cartilages had necrosed as a result of the treatment.

A case of cancer of the tongue and the floor of the mouth adherent to the jaw was next seen. The growth had been removed by diathermy in June, 1923. Two weeks later the external carotid was tied, and as much as possible of the metastasis in the glands excised by the same method. On Sept. 19 radium was buried in the remaining mass in the neck. When we saw the case there was a large open wound of the cheek, with at least an inch of the lower jaw exposed and necrotic, but it was asserted with confidence that this would separate as a sequestrum and that later a plastic operation would be done to deal with the defect.

It was stated that, as a general rule, the area of lymphatic drainage was not dissected out unless very obviously involved. For example, a case of epithelioma of the vulva was shown in which the growth had been excised locally by diathermy. The glands had not been touched, though on the left side they were very much enlarged. It was intended to treat them later on by X rays and to follow up the case.

On the other hand, in the treatment of any other metastatic mass clinically inoperable, as much as possible was removed, and the remainder treated with radium and X rays.

An operation for the removal of the breast for cancer by the diathermy method was then carried out. The case was one quite operable by ordinary methods. The passive electrode was fastened to the forearm of the same side. The anæsthetic used was chloroform, which was very well administered by a nurse. The breast was removed together with the axillary glands, the diathermy knife being used throughout. The dissection was begun along the origin of the pectoralis major from the ribs, and the whole mass was dissected up towards the axilla, together with both the pectoral muscles. There was no hæmorrhage whatever. As the axilla was approached the larger vessels were caught in clips, divided, and tied as soon as they were seen, in order to prevent the spread of thrombosis into the axillary vein, with subsequent risk of embolus. The axillary vessels were cleared and the gland was removed as if with an ordinary scalpel, and just as thoroughly. The fascia over the rectus abdominis was not touched. After removal of the breast, the whole of the large, raw area was cooked by diathermy, using both electrodes with flat terminals about one inch away from each other. Of course there was no possibility of getting the skin together, and, in fact, closure of

the wound is never attempted. The time taken for the operation was one hour. In favour of this procedure it was urged that there was less shock, there was no pain afterwards, and the removal of the growth was just as thorough as by ordinary dissection, and there was no risk of implanting cancer cells. It is claimed that, while by ordinary operative measures surgeons have to admit 25 per cent of local recurrences, this method gives only 5 per cent: as the method has been in use for only two years at the Institute, it was frankly admitted that it was much too soon to speak with any certainty. Moreover, apparently inoperable cases could be treated much more thoroughly; for example, if the growth was fixed to the ribs, the latter could be treated by diathermy and the cooking continued down to the pleura. The 'cooked' part of the ribs would subsequently separate as a sequestrum, and in one case the exposed surface of the lung healed into the wound. As a rule it took three months to granulate up after the operation; skin-grafting was not often necessary, and, if done, was usually unsatisfactory, owing to the fact that all patients were treated with X rays for six weeks after the operation. Several patients who had been operated upon by this method were then shown in various stages of their convalescence and after. They all agreed that they had suffered no pain; the use of the arm was excellent; there was no example of 'swollen arm', and the scars were soft and movable.

Dr. J. Heyman, who is in charge of the gynæcological cases, then gave us some statistics of cases of cancer of the cervix treated at the Institute. These had recently improved, as most of the gynæcologists now sent all their cases of cancer of the cervix for treatment, it being recognized that the results were better than those obtained by the Wertheim operation, and that a smaller primary mortality was involved. They were treated by diathermy, radium in uterus and vagina, and deep X-ray therapy.

Altogether this visit proved extremely interesting and suggestive, and was a great tribute to the work being done under the stimulating personality of Forssell. The way in which he displayed the efforts of his assistants was quite charming, and, as everywhere in Sweden, they were all so considerate as to address us in English, only occasionally having to be helped out by a Swedish surgeon from Kolmar, Dr. Edwin Helling, who acted as a willing interpreter and a delightful guide throughout the whole of our visit.

In the afternoon a visit was paid to the Clinic of Professor Jacobæus at the Serafimer Hospital. The Professor demonstrated his method of thoracoscopy on a case in which he had attempted to produce artificial pneumothorax for the treatment of tuberculosis of the right lung. The patient was a man about 23, a diabetic, who had been treated for this malady without success, and, as the Professor said, was 'surely lost', when insulin was tried with dramatic effect. The lung infection had developed after the diabetes. The skiagram showed that the lung had not collapsed, owing to an adhesion between the parietal and visceral layer of the pleura. The Professor thought that the adhesion was not very broad, and proposed to divide it with the electric cautery under direct vision by means of the thoracoscope. The operation was done under local anæsthesia. The patient lay on his left side with the right arm above his head. The thoracoscope was introduced into the right pleural cavity at the 7th intercostal space in the posterior scapular line.

After a short preliminary search the adhesion was found and demonstrated to all present. The special electric cautery, devised for this purpose, was then introduced through a cannula about one quarter of an inch in diameter at a corresponding point at the same level on the front of the chest. When the adhesion was half burnt through, the operation was stopped, in order to demonstrate to all present that this had been done. The division was then completed, and before we left the hospital a refill was carried out, and we were informed that examination by X rays showed the lung to be fully collapsed. The Professor afterwards demonstrated to us a large number of lantern slides, illustrating his methods and cases in this and other branches of medicine.

On Monday, Sept. 24, a visit was paid to Professor Einar Key's Clinic at the Maria Hospital (*Fig.* 352). This is an interesting old building, which was originally a private house, dating from 1675. In 1817 it was a factory, in 1850 a Maternity Hospital, and since 1905 it has been a surgical 'Lazaret'. Professor Key's private room dates from the first period, and is an interesting vaulted apartment, now decorated with mural paintings.

The first operation was a thoracoplasty for tuberculosis of the right lung in a woman, age 35. The local anæsthetic was 1 per cent novocain. Professor Key removed about 6 inches of half-a-dozen ribs, beginning at the 10th, up to and including the 5th. The anæsthesia was perfect. The operation took forty-five minutes. There was but little shock. The patient sat up after the operation and had the bandages applied. The operation is done by Professor Key in two stages, with an interval of two to three weeks. He made a great point that the angle of the rib must be included in the resected portion. The lower ribs should always be done in the first stage. In the second stage the upper four ribs—always including the 1st rib—are removed. It is not difficult to remove the 1st rib, if one works from below upwards, but it is very difficult—even dangerous—to begin with it. Key has an extensive experience of this operation, and we saw several cases in his wards. The patients usually come direct from the sanatoria for the operation, and then are able to return in from six to eight weeks. During their stay in the Maria Hospital they are treated in the general wards.

The next operation was for cancer of the stomach, but the glands were much involved and there were secondary deposits in the liver, so that no radical operation was feasible. Palliative gastro-enterostomy was not performed. The abdomen was opened in the middle line, and was closed with one layer of catgut sutures and then the skin sutures, no deep sutures being used.

Two cases were then operated upon for tuberculous epididymitis. The first was a man, age 30, whose left kidney had been removed seven years previously for tuberculous disease, and who now had both the right and left epididymis involved. A scrotal incision was used, and epididymectomy performed on each side, as much of the vas as possible being removed at the same time, but without extending the incision. The wound was closed without drainage after very careful hæmostasis. In the second case only the right side was involved, and epididymectomy was carried out in the same

way. In Dr. Key's opinion, this, rather than orchidectomy, is the operation of choice.

Dr. Key then went round his wards and showed several patients with tuberculosis of the lung who had been treated by thoracoplasty. The Professor also demonstrated, by means of lantern slides, the technique of Reissler, which he employs in the treatment of fractures. A woman, age 59, was operated upon for ununited fracture of the neck of the femur by insertion of a bone peg cut from the tibia. This was done in June, and the result seemed very satisfactory, but the patient had not yet been out of bed. In this method screws and nails are used rather than plates. The cortex of the bone is tapped to receive the head of the screw. He emphasized the point that fractures should be operated upon as soon as possible after their occurrence, and compared the urgency of operating upon fractures, particularly spiral

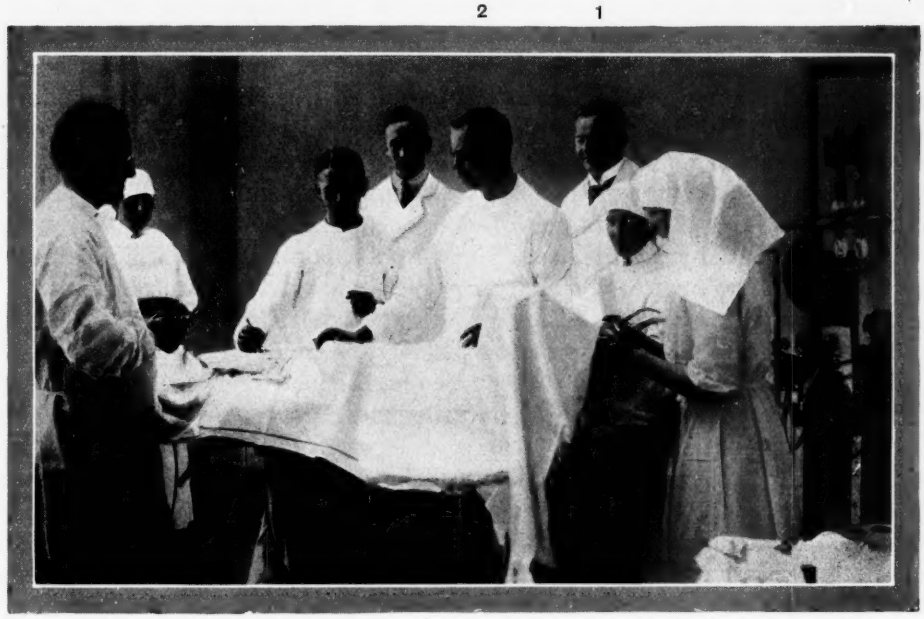

FIG. 352.—Professor Einar Key's Clinic. 1. Professor Einar Key; 2. Professor Akerlund.

fractures of the tibia, with the urgency of operating upon acute appendicitis and strangulated hernia. He also demonstrated, by means of lantern slides, a case of diaphragmatic hernia in which the stomach was in the thorax. An ulcer had developed on the lesser curvature and this had leaked. The stomach had been resected in the thorax by Polya's method, and then the hernial contents returned to the abdomen, and the opening in the diaphragm closed, the patient making an uninterrupted recovery. No abdominal incision had been made in this case. He showed lantern slides of another case, in which there had been difficulty in swallowing in a man, age 58. From the radiogram there appeared to be a tumour in the mediastinum; this was removed by transpleural operation, and turned out to be a large calcified gland.

Demonstrations were then made by the radiologist of the hospital, Dr.

Alsa Akerlund. He first showed his spiral secondary diaphragm, a modification of the Bucky-Potter diaphragm. The radiograms taken with the aid of this apparatus were excellent and showed much more detail than is usually seen. He also demonstrated a series of radiographs of duodenal ulcer, in which the findings were exactly analogous to those of gastric ulcer. The ulcer could be seen; there was a corresponding niche with retraction and an excentric position of the pylorus. Akerlund insisted that in order to obtain these results a careful technique was required, and especially an intimate co-operation between fluoroscopy and röntgenography. He recommended examination in an upright position.

On Sept. 25, we visited the Morby Hospital and Clinic of Dr. K. H. Giertz. This institution is seven miles out of Stockholm, and we were due at 8 o'clock, but the early morning drive through charming country was most enjoyable. He first operated upon a tuberculous kidney, using a lumbar incision, which was held widely open by a powerful rib separator. The kidney, with about eight inches of the ureter, was removed. The next case operated upon was an ulcer of the stomach with hour-glass contraction. The distal portion of the stomach with the ulcer was removed. The resection was commenced by ligaturing the right gastro-epiploic artery at the proposed site of section, thus enabling the lesser sac to be opened; this allowed traction to be made on the stomach, and it was contended that the coronary vessels were thus more easily identified and ligatured. The continuity of the gastro-intestinal canal was restored by uniting the jejunum to the posterior wall of the stomach by Roux's method en Y. The time occupied was one hour fifty minutes, great care being taken with the large amount of suturing which the method entailed. If the Polya method had been followed, the operation would probably have lasted just over the hour.

The Professor next operated on a case of osteitis fibrosa of the upper end of the left femur in a girl, age 16. The diagnosis was doubtful. Clinically it was tuberculous, but the radiologist said it was osteitis fibrosa. Some curious-looking material was scooped out of a cavity in the great trochanter, and the space left in the bone filled with a fat graft. The pathologist examined the material removed, and before we left the hospital we learned that he confirmed the radiologist's opinion. A series of cases were then demonstrated, including one of general thyroid malignancy, and two of general adrenal malignancy. Of the latter, in one case a tumour reported to be a hypernephroma had been removed from the left humerus, but no tumour could be found clinically in the renal regions; in the other a hypernephroma had been removed from the brain, but no renal tumour was demonstrable. This hospital has a very large amount of material, and we were informed that about 2000 operations were performed yearly by the Professor and two assistants. On the afternoon of our visit a further series of operations were carried out, including two other cases of resection of the stomach.

In the afternoon a visit was paid to Sabbatsberg's Hospital, to the Clinic of Dr. Hybbinette. This is the Municipal Hospital, and contains 800 beds. Dr. Hybbinette first demonstrated, by means of lantern slides, several cases of bone-graft, and afterwards showed the actual patients. They included bone-graft for syphilitic deformity of the nose, and for plastic operation on the

lower jaw after removal for tumour. In the latter case an excellent ramus had been made from the crest of the ilium. He then showed cases of arthroplasty of the hip-joint, the first case being one of congenital hip disease in a man, age 22. In this case a new acetabulum had been made with a burr, fat inserted into it, and the head of the bone fixed into the new joint by sutures through the capsule. The functional result was good after this operation, but there was inversion of the leg. The femur was therefore divided and the lower fragment externally rotated, so that the foot was in good position. The result obtained after the second operation was excellent, the man walking with great comfort and being able to flex the hip-joint. The second case of arthroplasty was undertaken for septic arthritis, which had produced ankylosis of both hip-joints and one of the knees, in a child, age 14. Arthroplasty had been done on the left side and osteotomy of the neck of the femur on the right side, with the object of making a pseudo-arthrosis. The knee-joint had not been touched. The result was very satisfactory.

Lantern slides were shown illustrating cases of recurrent dislocation of the shoulder-joint, particularly one in a man about 40 years of age. It was maintained that in these cases there is always a defect in the lower margin of the glenoid cavity due to fracture. If a radiograph is taken with the arm fully extended above the head, this defect can always be seen. Dr. Hybbinette treats such cases by a bone-graft from the tibia to fill up the defect. He does no slinging operation. He maintained that he got perfect results.

Two cases were demonstrated of myeloid sarcoma of the shaft of long bones, one being of the tibia, which was excised and a graft put in from the opposite tibia. The result shown was perfect thirteen months after the operation. The other case was that of a girl, who at the age of 16 had a spontaneous fracture of the left humerus, due to what appeared from the X-ray to be a myeloid sarcoma. This case was treated with splints and deep X-ray therapy. The fracture united and the sarcoma disappeared. As there was no operation, the diagnosis is in doubt in this case.

The last case shown was a woman, age 47, the subject of successful embolectomy. She had a valvular lesion of the heart. The embolus had lodged in the left femoral artery, where the profunda is given off. The operation was done six hours after the onset. The embolus was removed and the artery stitched up, and when we saw the patient, eighteen months after the operation, she appeared to be perfectly well, with normal circulation and function in the limb.

After the demonstration a visit was made to the wards and to the operation theatre. The first operation was an arthroplasty for ankylosis of the proximal interphalangeal joint of the middle finger following acute sepsis. The ends of the bone were shaped by means of a burr, and a graft of fascia lata was inserted between them after division of the extensor tendon; the tendon was stitched up after the fascia lata had been fixed in position. This was a troublesome little case, which was very nicely handled by the Professor and his assistants.

The next operation was a muscle-graft for paralysis of the quadriceps, the result of anterior poliomyelitis. The biceps and gracilis were grafted to the patella. The other leg had been similarly treated fourteen days previously.

On the same evening, we were entertained by the Swedish Society of Physicians at their weekly meeting. They meet in a commodious, three-storied building erected two years ago by the Society. On the ground floor there is a large lecture room, with accommodation for about 300, and here the weekly meetings are held; on the second floor is a large library with reading and committee rooms. The upper floor is used as a social club, and contains a spacious dining room, where supper is served after the meetings. The Swedish Society of Physicians was founded in 1808. It has met every Tuesday evening since, except during two months in the summer of each year, when no meetings are held. In addition to what might be called the General Meeting on Tuesday evenings, when papers of general interest are read and discussed, there are subsidiary sections embracing the various specialties; these meet on different evenings to discuss more 'specialist' papers. Many distinguished British medical men have been elected members: amongst others are the names of Astley Cooper (1813), Edward Jenner, Richard Bright, William Bowman, James Syme, Thomas Huxley, Joseph Lister (1881), Ronald Ross, Victor Horsley, John Langley, and William Osler. The Retzius Gold Medal has been awarded to Professor Langley (1912) and to Sir Charles Sherrington (1922).

On the occasion of the Club's visit, the first paper read was by Professor Aschoff on "Infection and Re-infection in Tuberculosis of the Lung". The Professor is an excellent speaker, and his address was very well received by the large audience.

He was followed by Professor Einar Key, who read a paper on the "Treatment of Tuberculosis of the Lung by Thoracoplasty", detailing his experiences of the operation since he commenced the series in 1915. He has operated upon 60 cases, and, though a sufficiently long period has not yet elapsed to judge of the ultimate result, at the present time, 4 out of the 7 cases operated upon in 1916, and 4 out of the 11 cases operated upon in 1917 are back at work and free from symptoms. Up to the year ending 1921, out of 51 cases operated upon, 15 are back at work and free from symptoms, 10 are improved, 5 were made worse, 5 died shortly after operation, 11 died subsequently of tuberculosis of the lung, and 5 of some other disease. The lecturer laid great stress on the necessity of doing the operation under local anæsthesia and in two stages. The paper was discussed by Professor Jacobæus, who had made the diagnosis and examined the chest in the cases related by Key, both before and after operation. He stated that in all but 3 of the 60 cases there were signs of the other lung being affected, as determined either by clinical examination or by X rays. The general rule is to wait for six months after deciding that operation might be of benefit. If at the end of that time there is no change in the less affected lung, then the worse side is operated upon. The disease on the less affected side may be aggravated after the operation, but the ultimate result on the whole may still be good.

Dr. Olivecrona then showed the specimen and read the notes of a case on which he had performed embolectomy of the right femoral artery on Sept. 22. This day was a Sunday during our visit, and the speaker had very kindly tried to get in touch with the members of our party, rightly

thinking that they would be interested in the operation. The case was of exceptional interest, as the patient had an embolus successfully removed from the left femoral artery twelve months previously by another surgeon.

The patient was a woman, age 40, who had suffered from valvular disease of the heart for many years. On many occasions there had been pulmonary emboli, and once an embolus in the right kidney. On Sept. 21 she noticed pain in the right foot. Next day at 2 p.m. the right foot and lower part of the leg became numb and the pain very severe. She was taken straight to hospital, and at 4 p.m. the diagnosis of embolus in the right femoral artery was made. The right foot was cold, and this coldness extended to a point five inches below the knee-joint. There was anæsthesia of the right foot to light touch, and the sensation of pinprick was delayed. No pulsation could be felt in the popliteal artery, but it could be felt in the femoral artery just below Poupart's ligament. A blood-pressure apparatus showed no oscillation when applied anywhere to the right leg, except just below Poupart's ligament. The exact site of the embolus could not be determined. The popliteal artery was first explored under local anæsthesia, but it was found empty. The femoral artery was next explored, and an embolus found to be lodged just where the profunda branch was given off. The circulation was controlled by clamps, the artery opened by a longitudinal incision, and the embolus removed. The artery was stitched up by a continuous suture of fine silk. When the wound made for the exposure of the popliteal artery was stitched up, there was good pulsation in the popliteal artery. Four hours later the foot was quite warm. The specimen shown had three clots attached, as if showing the division of the femoral artery into the profunda and superficial branches.

The development of the operation of embolectomy is largely due to Dr. Einar Key. An important paper on the subject by this surgeon was published in *Surgery, Gynecology and Obstetrics*, March, 1923.

On Sept. 26, we visited the old University town of Upsala, made famous in the history of surgery by the late Professor Lennander. A new hospital is well advanced in the process of building. The old clinic, dating from 1860, is still in use, and it was there, in a very old-fashioned operating theatre, that we found Professor Nystroem at work.

The first operation performed was for fixation by the Albee method in tuberculous disease of the spine. The patient was a boy, age 14, who had been treated by Professor Waldenström's method for six months, whereby the angular curvature had been reduced from 90° to 30°. Scoliosis was present as well. It was notable that the Professor did not wear gloves. The usual curved incision was made, the spines above and below the site were divided by a circular saw, and the division was deepened by a chisel and hammer. The graft which was taken from the tibia included the periosteum.

The second operation was undertaken for a fracture of the right humerus four months previously in a woman, age 65, in which a false joint had formed. This was a very difficult proceeding. Ultimately the bones were got into good position, and a bone-graft taken from the tibia was inserted.

He then demonstrated some cases, more especially his method of treating large chronic ulcers of the leg. In all cases the Wassermann reaction was

done first. If any varicose veins were present, these were excised as a preliminary operation, but the rarity of their occurrence in these cases was commented on. As a preparatory treatment, patients were kept at absolute rest for two weeks, during which the ulcers were dressed with subacetate of lead. The operation consisted of a very wide and free excision of the whole ulcer, well beyond the apparent edge, with all the scar tissue down to the muscles and tendons. All fascia was excised, but the periosteum of the tibia was carefully preserved. Hæmostasis was attended to most carefully, and then the whole surface was immediately skin-grafted by the Thiersch method. A very porous dressing was applied so that any discharge could get through. The anæsthesia was either local or spinal. In the cases shown the ulcers

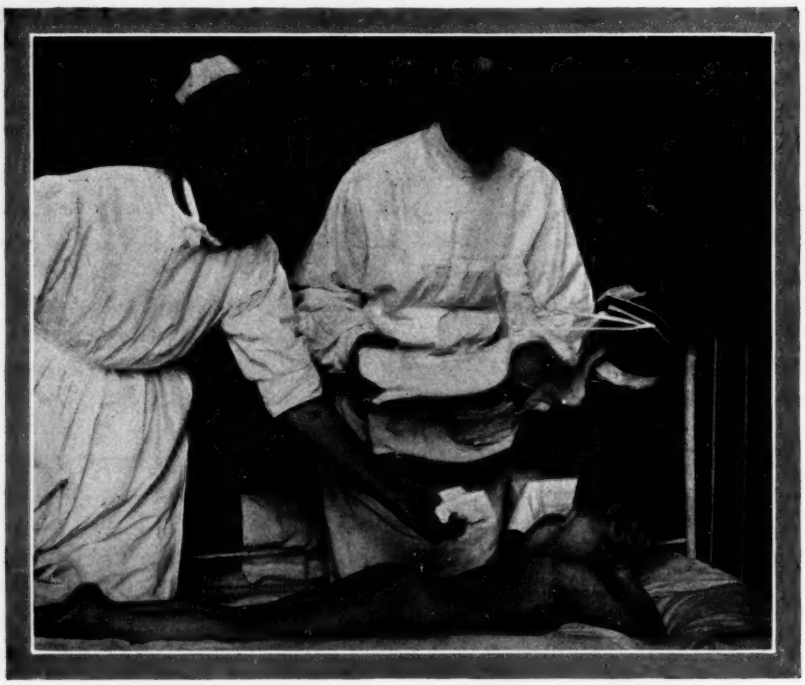

FIG. 353.—Professor Waldenström demonstrating his method of preliminary treatment of kyphosis in tuberculous caries of the spine.

were healed. No details as to the number operated upon were given; second operations had sometimes been done.

Dr. J. W. Nordenson gave a demonstration in the Ophthalmic Department of Professor Gullstrand's lamp and ophthalmoscope. With the latter the disc and macula was seen magnified one hundred times.

Some of the members visited the Department in charge of Professor Bárány, of international otology fame.

In the afternoon a visit was paid to the old anatomical theatre of Upsala, where public dissections were made in the time of Olaf Rudbeck (1630–1702), the Swedish anatomist, who shared in the discovery of the thoracic duct.

On Sept. 26 the Clinic of Professor Henning Waldenström at St. Gorans

Hospital was the rendezvous. In the wards we saw patients undergoing various forms of treatment. The cases were all children, and mostly examples of tuberculosis of the bones and joints. Those in the Finsen light rooms included bone tuberculosis with sinus formation and cases with amyloid disease. All showed remarkable improvement under this treatment. Details of the treatment of tuberculous disease of the spine were fully discussed. Before doing any operation for fixation in these cases, great stress was laid on the necessity of the preliminary treatment to reduce the kyphosis as much as possible. This was done by rest and splinting by the 'Waldenström' method, which is much as follows: Immediately on admission the child has a plaster jacket accurately fitted to its back while it is lying on its belly supporting the chin with both hands, the elbows being on the bed. This jacket is then suitably padded, and the child lies in it until the gibbosity disappears or becomes stationary. The jacket is raised from the bed by a wooden support so that the spine is extended. The child is never allowed to sit up for any reason whatever. It is turned by two nurses, one at the shoulder, the other at the buttocks. Each week more wool is put into the jacket under the gibbosity, so that the pressure on it is increased (*Fig.* 353). The average length of time for this preliminary treatment, preceding operation, is eight months. So far as the graft is concerned, the Professor insisted that it must extend at least the length of two vertebræ above the disease and two below.

An operation was done on such a case in which this preliminary treatment had been carried out. The spines were split with a Hey's saw and the cut was deepened with a knife; there was very little trauma. The graft was taken from the tibia and included the crest. In adults it is impossible to get cancellous bone if the crest only is taken; it is therefore cut from the subcutaneous surface of the tibia. The graft in the case we saw was fixed in position by silk ligatures. The patient's own jacket is replaced after the operation. He is turned only twice in two months. After being in bed for two months he is allowed up with a corset. The case operated upon would wear a corset for a year at least. Professor Waldenström then gave a lantern demonstration of his method of treatment. He had operated upon 101 cases in the last ten years. The results shown were excellent, and included patients of all ages.

This brief account of our visit supplies only an outline of what we saw; but it would indeed be incomplete if it did not mention the many kindnesses and the unbounded hospitality which met us everywhere.

A STUDY OF INTRACTABLE PAIN RELATIVE TO RHIZOTOMY AND SPINAL SECTION.

By R. C. SHAW, Manchester.

At a meeting of the Surgical Section of the Royal Society of Medicine in 1911, Mr. Hey Groves, in a paper on rhizotomy, drew attention to the fact that whilst section of the posterior spinal roots was followed by fairly satisfactory results in cases of spastic paralysis, this procedure was not effectual for the treatment of intractable neuralgias. There was a failure of rhizotomy to cure pain in about 75 per cent of cases. Again, in a paper published in the British Journal of Surgery of October, 1914, a synopsis of the results of rhizotomy in the hands of its leading British exponents showed very little progress towards the permanent cure of pain of this character. An analysis of 15 cases of rhizotomy exhibited 8 complete cures, but of this number 3 had pain in a strictly localized peripheral area involving only one spinal root, and were relieved by division of that root, a feature which places these examples in a group peculiar to themselves, contrasting strongly with the large majority of cases with intractable pain treated by rhizotomy. Thus, of the 8 cures, only 5 may be said to typify the average form of case encountered. Of the remainder of the 15, 4 were complete failures, and 3 may be discounted owing to complications. Turning to the results of posterior rhizotomy for the painful crises of tabes dorsalis, the figures are more encouraging; in Förster's hands the percentage of completely cured is given as 49, and of the remaining 51 per cent which represents total failures and cases improved but not cured, the latter form 33 per cent, whilst the English percentage of cures would appear to fall below these figures.

The failure of posterior rhizotomy to abolish pain in the great majority of these cases is a striking feature when compared with the successful post-operative results following excision of the Gasserian ganglion in cases of persistent trigeminal neuralgia. In 1902 Krause had had no recurrence of pain in any of his 36 cases of gasserianectomy, whilst Keen in 1898 had 2 relapses out of 14 cases, and these were due to incomplete operation. Morphologically the Gasserian ganglion corresponds to the ganglia on the dorsal spinal roots, being anatomically in association with the same type of fibre; and yet we are faced with the anomaly of divergent results on extirpation of these structures, pain invariably being relieved in the one case, but in the spinal region frequently recurring. In this association it may be apposite to draw attention to the fact that a psychical element, although indubitably present in many cases of long-standing pain, as shown by a variable degree of hysteria, is not in any way accountable for the majority of failures in spinal rhizotomy; for, in the first place, cases exhibiting pronounced hysterical symptoms have been definitely cured by root resection; whilst in none of these cases is the pain more severe than in those of trigeminal neuralgia,

which from its anatomical situation and connections one might expect to make a more pronounced psychical impression than, for example, an equally severe pain in the lumbar region; and yet, as we have seen from the post-operative results, root-resection or extirpation of the ganglion of the fifth nerve is an eminently satisfactory procedure, factors which weigh heavily against a psychological explanation of the failures in dorsal rhizotomy.

The persistence of the pain after the severance of what is held to be the principal afferent path to the central nervous system gives grounds for the supposition that an accessory-sensory channel may exist.

In studying the results of posterior rhizotomy, the phenomena may be divided into two groups: (1) *Objective*; (2) *Subjective.*

Objective Symptoms.—In this group we have for consideration the resultant anæsthesia. Dealing primarily with the cervico-dorsal rhizotomies, the cases fall into two classes: those which present complete anæsthesia to all the usual stimuli, and those in which it is incomplete. Among the latter is a case of Horsley's, reported by Head, of posterior rhizotomy of the 5th, 6th, and 7th cervical roots for neuralgia. In this subject there was no loss of deep sensation above the wrist, nor of vibratory sense in the forearm and arm. In such a case there is always the possibility of overlap from the 8th cervical or 1st dorsal roots. Hey Groves reports a case in which he performed rhizotomy of the 6th, 7th, and 8th cervical and 1st dorsal roots for spastic paralysis of the arm, in which the anæsthesia was confined to a strip along the ulnar side of the hand and forearm, including the little and ring fingers, and ceasing two inches above the elbow. The spinal segments usually assigned to the forearm and hand are the 6th, 7th, and 8th cervical and 1st dorsal. Are we to accept this case as an example of extensive overlap from the 5th cervical? A patient of Sir William Thorburn's, where resection of the lower four cervical and 1st dorsal posterior roots had been performed, manifested deep sensibility everywhere in the affected arm, whilst cutaneous anæsthesia was very patchy. An interesting light is thrown on the behaviour of these areas of sensation after posterior rhizotomy by the following two cases.

In the first example, a patient of Abbe's suffering from brachial neuralgia, the left 6th, 7th, and 8th cervical and 1st dorsal posterior roots were resected, followed by complete anæsthesia in both front and back of the left hand, extending one to two inches above the wrist, and also on the dorsum of the forearm, and the side and dorsum of the upper arm to about halfway above the elbow; elsewhere sensation was completely retained. Re-examination of the same patient seven years later demonstrated only diminished tactile sense for the ulnar and median distribution, with analgesia over the same area, whilst above the elbow there was no gross disturbance of sensation.

The other case, a patient of Bennett's, was suffering from acute crises of pain in the left leg which had proved intractable to peripheral operation. Posterior rhizotomy was performed on the lower 4 lumbar and 1st sacral roots; immediately following operation, anæsthesia was complete in the limb areas corresponding to the severed roots; but during the remaining twelve days, before the patient succumbed to a cerebral hæmorrhage, there was a steady and progressive restoration of sensation in the anæsthetic area, so much so that the operator was satisfied that if the man had lived the restoration

would have been to an almost normal degree. Post-mortem examination showed that there had been no re-union of the severed roots.

It will thus be seen from these two widely separated cases that there may be a slow or rapid regain of the lost sensation in the areas of the cut roots. From the objective side alone it is clear that some further explanation of the incomplete anæsthesia and recovered sensation must be sought beyond that of nerve overlap from adjacent unsevered roots.

Turning to the cases of pain crises in tabes dorsalis, a similar inconsistency of the effects of posterior rhizotomy on the objective sensory phenomena may be instanced, both of which passed under personal observation. In the first case, suffering from severe gastric crises, Sir William Thorburn had performed posterior rhizotomy of the 5th to the 9th dorsal roots, with resultant complete anæsthesia of the skin from the 5th rib to the umbilical plane on the left side, whilst a tactile sensation was retained in the muscle wall, deep pressure stimuli being localized to within one inch of the point of maximum stimulation. In the second case, also for gastric crises, the same operator had resected bilaterally the 5th to the 8th posterior dorsal roots. Examination of this patient six years later showed a corresponding cutaneous anæsthesia from the level of the 5th rib to a plane passing a little above the umbilicus ; but, as in the former case, tactile sensation in the deeper tissues was perfectly retained over this entire area, the stimuli being fairly accurately localized. The laxity of the skin in both these subjects rendered it an easy matter to stimulate the same apart from the deeper tissues, the patient being entirely unaware of the strongest pressure or prick stimuli, whereas the slightest pressure on the muscle wall was readily appreciated.

Subjective Symptoms.—Under this heading the effects of posterior rhizotomy on pain will be considered, primarily in the limbs. Of the large proportion of neuralgia cases that relapse after operation, some have recurrence of pain immediately after recovery from the anæsthetic, whilst in others relapse does not occur until weeks or even months have passed. Considering the former first of all, in a case of Abbe's where the 6th, 7th, and 8th cervical and 1st dorsal posterior roots were resected, the patient was free from pain on the first day, but the symptoms gradually returned, and by the fifth day an attack of the former pain had been experienced in the outer side of the forearm, and hand. After fifteen days the attacks lessened, and from that date, for the next seven years, pain was still felt, although it was not so frequent or so severe as formerly. It is evident from this case that part of the trouble was due to irritation of the posterior roots, a supposition confirmed by the pathological examination of the resected roots, which showed inflammatory changes ; but it is equally clear that some other sensory channel was also being irritated. A similar inference may be made from a case reported by Chavannaz. The patient, suffering from severe intercostal neuralgia radiating from the axilla to the mamma, had the corresponding intercostal nerves resected without any relief ; rhizotomy of the 1st to 4th posterior roots of the dorsal nerves only lessened the pain to a slight degree, suggesting, as in Abbe's case, that another sensory path was functioning, although the posterior roots must have participated in the conduction of the irritant stimuli.

Contrasting with the rapid recurrence of the subjective symptoms as

typified by these cases, there is a second group which show relapse after an interval often lasting several months. A man of 62 years, suffering from acute pain in the right leg, is reported by Hildebrand as having five posterior lumbar roots resected, the symptoms being completely relieved for nine months, when the pain gradually returned to its former severity. Similarly, a patient of Knapp's, a man of 25, with excruciating neuralgia in an amputation stump of the right arm, had the 6th cervical to the 1st dorsal posterior roots resected, with relief for several months, when the pain returned as severe as before, so much so that the spinal theca was again opened and the division of the roots confirmed. A case of Hey Groves's, suffering from persistent neuralgia of the left leg, the result of an indolent ulcer over the shin, had posterior rhizotomy of the 4th and 5th lumbar and the 1st, 2nd, and 3rd sacral roots. After operation there was complete anæsthesia of the affected limb, accompanied by ataxia, demonstrating that all usual forms of sensation, including kinæsthetic impulses, had been eliminated along with the pains; the latter, however, recurred after a lapse of several months, eventually driving the patient to acute mania. Although there was an undoubted mental disturbance in this case latterly, the psychical affection might be reasonably attributable to the effects of pain, rather than the pain to be cerebral in origin.

In these cases it would appear that some new channel of irritation was gradually opened up under the influence of chronic irritation, until the strength of the stimuli again produced conscious recognition of pain.

The same general division with respect to relapse is evident in the tabes cases, some having recurrence immediately after operation, others relapsing only after several months. Again, with regard to the effects of rhizotomy on those that recur, many are considerably modified both in respect to the frequency of the attacks and the severity of the pain. About 27 per cent of 64 cases of Förster's were altered in this way, against 26 per cent of total failure, showing that, as in the rhizotomies for neuralgia, the posterior roots indubitably share in the mediation of the stimuli; otherwise it is difficult to account for the modification of the pain after their section.

From the preceding review of the clinical effects of rhizotomy one may make certain general inferences.

1. That the posterior roots are actively concerned in the conduction of stimuli in the majority of cases. Where posterior rhizotomy cures, this is self-evident, whilst the considerable alleviation of the symptoms after their section in cases that relapse points to the same conclusion.

2. That in some cases of posterior rhizotomy of the cervico-dorsal or dorsal region, there is retained a sensibility to pressure in the deep tissues; and that this has been recognized in cases where overlap from normal areas is out of the question.

3. That in one case there was a rapid return of sensation in the anæsthetic area although five posterior roots were cut, which latter fact was confirmed on post-mortem examination.

4. That in other cases there is no evidence of any retained sensibility to ordinary stimuli, although the pain persists.

5. That the recurrence of pain, whether early or late, without evidence

of psychical disturbance in many cases, suggests that another conducting channel may exist.

Before proceeding to examine the subject from the physiological side, the indications from three clinical cases as to the nature of this path will be discussed.

Case 1, a patient of Thorburn's, was a man of 47 suffering from gastric crises of the painful type, of tabetic origin. The pain was principally seated in the 7th, 8th, and 9th left intercostal spaces and the left epigastrium, accompanied by a localized pain in the latter region. Unilateral posterior rhizotomy of the 4th, 5th, 6th, 7th, and 8th dorsal roots was performed in 1914. At the time of operation it was thought that some of the corresponding anterior roots had been severed, which was confirmed by the atrophy of the intercostal muscles that followed operation. On re-examination of this patient in 1921, the 6th, 7th, and 8th intercostal muscles were seen to be paralysed, accompanied by marked wasting in the corresponding spaces. The area of anæsthesia was found to extend from the 5th rib to the subcostal plane on the left side, and to be complete for both skin and deeper tissues. The patient had not suffered the slightest relapse since the time of his operation. Comparing this case with the two previously mentioned of this surgeon's, the contrast is striking; both the latter had retention of deep sensibility and recurrence of pain, and in both posterior roots only were divided, whilst in the present case anterior roots were also cut. This may be mere coincidence as regards the cure of pain; but, on the other hand, the abolition of deep sensation where the ventral roots were divided is very suggestive of the possible secondary path in these cases.

Case 2 is reported by Kilvington. The patient, a male, age 21, suffered from neuralgic pain in the stump of the left arm after amputation for sepsis following old fracture-dislocation of the elbow. Prior to rhizotomy, resection of nerves had, as usual, failed to relieve the symptoms, the patient always complaining of pain on recovery from the anæsthetic. Finally, rhizotomy of the 6th, 7th, and 8th cervical and 1st dorsal roots was carried out, the section being made extradural, but central to the posterior ganglia, and in each case anterior as well as posterior roots were divided. On recovering from the anæsthetic the patient immediately said that the pain had gone, a relief which stands out in striking contrast to the effects of his previous operations; and up to the date of report, ten weeks after, there had been no recurrence.

Case 3 was a patient of Abbe's, where a man of 46, suffering from old infantile hemiplegia with athetoid movement of the right arm, had increasing neuralgia in the forearm; the arm was amputated at the shoulder, a proceeding which only exaggerated the pain. Rhizotomy was performed, and the 5th, 6th, 7th, and 8th cervical and the 1st dorsal posterior roots, with the 6th, 7th, and 8th cervical and 1st dorsal anterior roots, were resected. The results were very satisfactory: the painful spasm and athetosis were permanently abolished, the scar of the amputation became painless, and the health greatly improved, although the patient still said he had slight pain, which Abbe attributes to a psychical factor in view of the old-standing cerebral trouble. However, it is clear from the complete cessation of all the major symptoms following root resection that the trouble was principally located peripherally.

The definite cure in the first two cases, including the absence of deep sensation in the tabes case, with the great relief of the last patient despite old-standing cerebral trouble, strongly indicates the ventral roots as the possible accessory channel of conduction of pain impulses. Such would appear to be the general inference from the clinical side, from which we may turn to the physiological investigation of the anterior roots as an afferent path.

THE PHYSIOLOGICAL INVESTIGATION.

In the first place, it should be noted that practically all our knowledge of sensory fibres in the ventral spinal roots dates not from recent years, but from the days of Claude Bernard and his predecessor Magendie. More recent work has been confined to degenerative methods of study, on the principle that an endoneural afferent system did not exist, all sensory cells being considered to lie in the extraspinal ganglia. Since it is only the actual physiological responses that can finally settle whether a fibre conveys a sensory impulse or not—evidence which can only come from the clinician or the experimental physiologist—it is of vital importance to the question to sift completely the classical experimental work on this subject, work which has formed the basis upon which our conception of the function of the anterior roots has been built, and which, for general reasons to be seen later, is unlikely to be repeated under its original conditions.

At the beginning of the last century physiologists first made an attempt to distinguish the functions of the dorsal and ventral spinal roots. Walker, in 1809, considered that the anterior roots conducted sensory impulses, and the posterior to be motor in function ; Lamarck in the same year independently conceived the same idea. It was not until the advent of Bell's work in 1811 that any accurate general conception of the functions of these roots was attained ; this investigator, using freshly-killed rabbits, was able to demonstrate the motor nature of the anterior roots, but did not succeed in elucidating the sensory function of the posterior ones. His pupil Shaw went to Paris in 1821, and demonstrated these experiments in the presence of Magendie, who commenced research on this subject, and succeeded in proving the general sensory nature of the posterior roots, at the same time confirming the efferent character of the anterior roots. But it is to be noted that Magendie, with scientific integrity, published his contradictory evidence with respect to the latter series. In 1823 he says, " The signs of sensibility are hardly visible in the anterior roots " ; whilst in 1839, speaking of the same nerves, he refers to their sensibility as being very manifest. Nevertheless, other workers in this field proved that the general principles of the Bell-Magendie law were also applicable to birds, fishes, and batrachians ; the frog of Muller is well known as showing complete anæsthesia on one side and paralysis on the other side of the body, following section in the first instance of posterior, and in the second case of anterior, roots.

The question of the apparent sensory element in the ventral roots was investigated by Longet, who declared the non-existence of the same in his work, published in 1842 ; but research on the subject was continued by Bernard, who, after many experiments, succeeded in showing conclusively that sensation was present in the anterior roots, which he concluded to be due to the presence of recurrent sensory fibres passing from the posterior ganglia up the anterior roots to supply the spinal meninges. It was found that if a ventral root were severed, stimulation of the peripheral stump alone gave rise to a response in the animal, and that this result was dependent upon the integrity of the dorsal root. It was likewise observed that division of the mixed nerves distal to the junction of the two roots also abolished the sensibility

of the ventral root; from which evidence this investigator concluded that these recurrent sensory fibres crossed from the dorsal to the ventral roots, not at their point of union, but in the distal plexuses. The general principles of the Bell-Magendie law were re-studied by Waller, using degenerative methods, and reconfirmed thereby. From time to time, however, non-degenerated fibres were reported in the central end of severed dorsal roots when cut proximal to their ganglia, and the question was finally decided by Tanilli and Panichi in 1902. Using dogs for their experiments, they cut the posterior roots and, allowing for degeneration, stained them by the Marchi process; their results showed that the central end contained a few undegenerated and scattered fibres, whilst the corresponding peripheral stump showed similar degenerated ones. It was also noticed that whilst in the cervical and dorsal regions there were only a few of these fibres, they were more numerous in the lumbar segments. From the embryological side, Cajal has observed fibres, arising as axons of cells in the grey matter of the spinal cord of chicks, growing out by the dorsal roots. The evidence, therefore, from histological and embryological sources demonstrates an exception to the general law in the case of the posterior roots; while the results of experimental stimulation such as was carried out by Bayliss and by Steinach in the frog have shown that motor effects follow stimulation of the same, but that the effects are dependent upon fibres possessing trophic cells in the dorsal ganglia, which evidence shows that there are at least two exceptions to the normal process of conduction and cell-connection of the fibres in the dorsal roots. The case for the anterior roots was investigated by Schiff in 1850, by section and staining for degeneration, which methods revealed the presence of degenerated fibres in the central ends of these severed roots, confirming the conclusions of Bernard with respect to recurrent fibres possessing trophic cells in the posterior root ganglia.

In view of the fact that all our knowledge of the sensory responses to stimulation of the ventral roots comes from the work of Claude Bernard, it is necessary to review carefully the general results of these experiments. The laminectomies were performed on dogs without anæsthesia and often accompanied by considerable hæmorrhage, whilst the actual testing for sensibility was carried out by pinching the nerve-roots; a positive response elicited a definite cry or movement of the animal. In many of his earlier experiments no signs of any sensory perception were evoked, when in 1846 he appears to have succeeded suddenly in obtaining positive results. A careful study of these shows that the responses which are interpreted collectively in reality fall into two definite groups: (1) Cases where sensation was found only on first stimulation of the roots, immediately subsequent to exposure of the cord after great hæmorrhage, and consequently when the animal was in a condition of maximum shock. In these cases the sensation rapidly diminished. (2) Cases where the response was only obtained after allowing the animal to rest for an hour or two following exposure of the cord, thereby permitting the abatement of shock. These facts suggest that the sensory responses are due to widely different factors.

The type of sensation elicited on first exposure and stimulation of the roots is strictly comparable with the sensory phenomena following the stimulation

of the afferent visceral nerves in man; in the latter, results were obtained over a transitory period in cases where the viscus, such as the pelvic colon, was exposed outside the peritoneal cavity. It is therefore possible that this form of sensation is dependent upon a similar type of nerve-fibre passing over or through the anterior roots, but whether of recurrent meningeal nature or true afferents to the spinal cord it would be unwise to differentiate.

The second form of sensory response obtained after the subsidence of the major shock appears to be explainable in an entirely different manner. The results were only obtained on stimulating the peripheral end of the cut root, which necessarily caused contraction of muscle. That such a muscular contraction is capable of alarming an animal, is borne out by observations noted during experiments to be detailed later, where stimulation of a muscle through the anæsthetic skin following section of three posterior roots resulted in a contraction which alarmed the animal, presumably by exciting unaffected nerves. This result would be more pronounced in Bernard's experiments, where the posterior roots were intact, whilst the abolition of the phenomenon on section of the mixed nerve or the posterior root is quite intelligible.

It is equally evident that when the animal was in a condition of shock such a response might not be obtained, whereas an interval of an hour or two would permit this condition to pass off, whilst the irritable effects of trauma would have increased the excitability of the nerve-fibres. Otherwise it is difficult to conceive that the afferent fibres to the spinal meninges pass from the dorsal root ganglia to distal plexuses and then double back up the motor nerve to their distribution; and, what is more, the spinal meninges are almost insensible to manual stimulation. This was shown in the human subject by a case of Abbe's where the opening of the dura without anæsthesia was unattended by pain. We may glean from these observations that although the general principles of the Bell-Magendie law hold good, there are exceptions to it in the posterior and anterior roots.

The investigation of this hypothetical afferent path was commenced from the histological side on the principle of nerve-degeneration following section of the fibres from their trophic cells. In this connection two possibilities present themselves: (1) The trophic cell might be in the extraspinal ganglia, such as those on the posterior roots or in the sympathetic chain. (2) The cell might be intraspinal; for example, in the lateral horn nucleus or in Clark's column. (*Fig.* 354.)

If the former were the case, section of a ventral root would produce ascending degeneration of the afferent fibres in the root, and in the columns of the cord, provided no secondary neurone were intercalated on the tract immediately after the arrival of the axon in the grey matter. If the trophic cell were situated in the spinal cord, section of an anterior root would result in degeneration of the afferent fibres on the peripheral side of the division, which would not be distinguishable from the degenerated efferents. We primarily investigated the effects of anterior rhizotomy in cats. Following a laminectomy, an anterior root was hooked into view by a fine wire and divided by an ocular tenotome; from fourteen to twenty-one days were allowed for degeneration, when sections of the spinal cord were taken and stained by the Marchi process. The earliest results obtained showed definite

degeneration in the posterior columns, even in cases which appeared to have been carefully treated, without any known contusion of the spinal cord; but the later results, following increased efficiency in the operative technique and more expeditious procedure, showed no trace of degeneration in the spinal tracts. Sections in all cases were cut transversely above, below, and at the level of the lesion, and also longitudinally. As the result of this negative evidence the presence of afferent sensory fibres possessing a trophic cell outside the cord would appear to be eliminated.

The other possibility, that of afferent fibres with endoneural trophic cells, cannot be excluded by these experiments. At one time it was under consideration to produce mass degeneration of known tracts in a selected segment of the cord, on the principle that the endoneural cell axons would remain unaffected. Such a procedure would involve double transverse section combined with

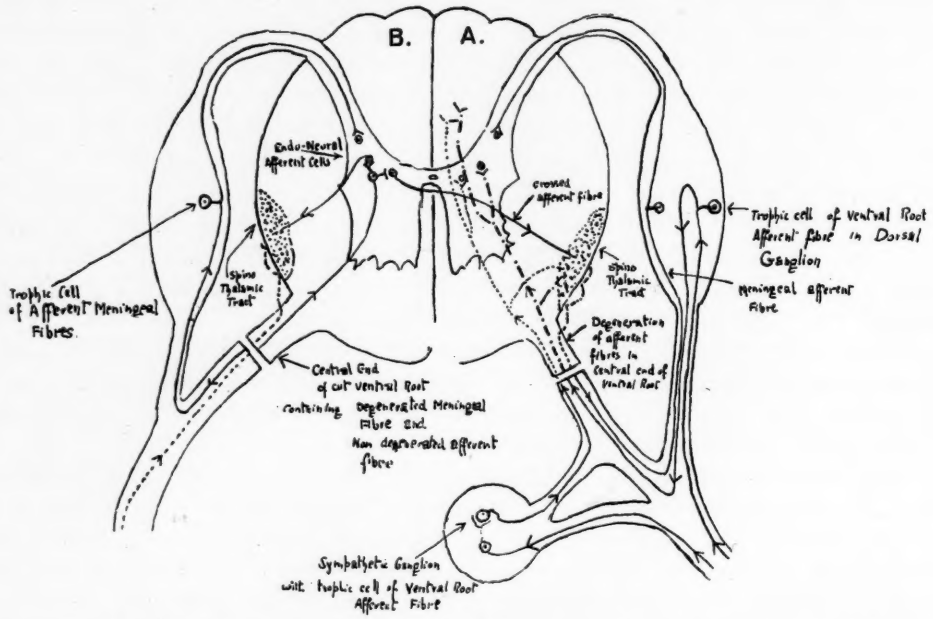
B.
A.
Endo-Neural Afferent Cells
crossed afferent fibre
Trophic cell of ventral Root Afferent fibre in Dorsal Ganglion
Trophic Cell of Afferent Meningeal Fibres
Spino Thalamic Tract
Spino Thalamic Tract
Meningeal afferent Fibre
Degeneration of afferent fibres in central end of ventral Root
Central End of cut ventral Root containing degenerated Meningeal Fibre End
Non degenerated afferent fibre
Sympathetic Ganglion with trophic cell of Ventral Root Afferent Fibre

FIG. 354.—Diagram illustrating hypothetical degenerations after section of anterior root afferent fibres from (A) extraneural trophic cells, (B) endoneural trophic cells.

rhizotomy of the roots supplying the segment; unfortunately, a fallacy would arise from the ascending and descending collateral fibres, themselves arising from cells in the grey matter. As an alternative it was decided to investigate the effects of rhizotomy on somatic sensibility. Rabbits were the animals selected for these experiments.

Before proceeding to a description of the experiments and their results, the methods of examination for sensation will be described. In the first place it is evident that the response of an animal to a sensory stimulus will vary considerably according to its condition and the surroundings, and that, apart from the signs of actual pain perception as shown by a cry or violent struggling, it may appreciate many grades of tactile sensation before such stimuli arise

to consciousness as harmful—sensory appreciation which it is of the first importance to be able to recognize.

As the result of repeated study of rabbits, it was noticed that, when examined under quiet conditions, if the head were lightly stroked, the ears were depressed to a medium degree, the palpebral aperture was contracted, and the head was held still: the general impression was one of rest. If the stroking was now stopped, the animal usually remained in this attitude for several minutes. It may be mentioned at this juncture that the animals were housed close to the street; consequently, the ordinary sounds from without did not disturb them in the least. When the rabbit had been quietened into the 'rest' attitude, the application of a slight stimulus to a normally sensitive skin area arrested its attention, which was outwardly manifested by a raising of the ears and a dilatation of the palpebral aperture; whilst if the stimulus was slightly increased, the ears became erect, the eyelids were widely opened, and the head was held in a strained attitude of attention which frequently caused it to oscillate; at the same time the respirations might be found to be quickened. This degree of stimulus sometimes caused rabbits to look round at the leg that was being pinched, without any signs of alarm or struggling which would suggest pain. The attitude was one of 'awareness'. If the stimulus was now raised to a painful degree, the animal depressed the ears strongly, at the same time struggling to move away if restrained, but only a very painful stimulus evoked a definite cry. By making repeated observations at different occasions on the same animal, one was able to appreciate the manner in which the animal responded to the different degrees of stimulation; at the same time frequent observation of the similar type of response eliminated fallacies from adventitious movements.

As for the mode of stimulation, the faradic current was first employed, but it was soon found to be useless on account of the buzzing sound distracting the animals' attention, causing them to be constantly on the alert. For this reason it was not used, the simple pinch-prick stimulus with a sharp pair of forceps being found quite effective.

The line of investigation first adopted was to examine the effects produced on somatic sensation by posterior rhizotomy, following on the indications from the human results, the dorsal region being primarily studied.

EXPERIMENT 1.—Rabbit. Laminectomy mid-dorsal region. Posterior rhizotomy, three consecutive roots on left side.

Result.—There was complete cutaneous anæsthesia over an area about ½ in. wide, extending obliquely round the body to the mid-ventral line. The deep tissues in this area everywhere responded to pinch-prick. Faradic current elicited a slight response over this area, as compared with a very active result on normal skin. In this experiment the possibility of overlap from adjacent nerves for the supply of the deep tissues cannot be discounted, although it should be noted that the response to pinch-prick stimulus was equally evident throughout the entire anæsthetic belt.

EXPERIMENT 2.—Rabbit. Laminectomy. Posterior rhizotomy of four right dorsal roots.

Result.—Cutaneous anæsthesia about 1 in. wide extending obliquely round the body to the upper part of the epigastrium. The rabbit responded to stimulation of a normal area by at once depressing the ears and widely dilating the palpebral aperture. This response was always obtained on stimulating the deep tissues within the anæsthetic belt. It was found that, if this manifestation was evoked, stroking

the animal whilst the stimulus was maintained quietened it again, after which a further increase of pressure was requisite to excite the same response. The additional increased excitation required was now found to be very considerable, the animal remaining perfectly tranquil in the 'rest' attitude, even though great pressure was being exerted; then suddenly it appeared to appreciate this increased stimulus, which was probably due to visceral disturbance such as respiratory embarrassment. Throughout these procedures the animal was counter-supported with a cotton-wool pad; otherwise the slightest displacement would cause alarm.

The experiment shows two distinct sensory responses: (*a*) An early appreciation when the deep tissues were pinched, a response that was merely characterized by an attitude of 'awareness'; (*b*) The late response, probably from visceral disturbance. The accidental fracture of a rib in the area of anæsthesia was definitely appreciated.

EXPERIMENT 3.—Rabbit. Division of three dorsal posterior roots on right side.

Result.—Total anæsthesia of skin and deep tissues over a belt ½ in. wide, extending obliquely round the body—a result which shows that deep sensation is not retained in every case after dorsal rhizotomy.

The difficulty of stimulating a localized body area, with possibly fallacies from visceral responses or through innervation of superficial muscles, decided one to turn to the limbs for a more decisive field, the objective being the section of the total afferent supply to a single member by posterior rhizotomy. This was primarily attempted in connection with the fore-legs, but failed through death from shock always supervening; but in the case of the hind limb the animals withstood the operation more satisfactorily, although the average mortality was never less than 28 per cent.

In rabbits the anterior crural arises in most cases by one large root between the 6th and 7th lumbar vertebræ, and by two smaller roots above this, passing out between the 5th and 6th and the 4th and 5th vertebræ respectively, the uppermost root being very small. The obturator arises from the 6th and 7th lumbar roots, whilst the sciatic has four large roots from the 6th and 7th lumbar, and the 1st, 2nd, and 3rd sacral.

It will be seen that section of the posterior roots of the last four lumbar nerves and the first two sacral, combined with a transverse section of the spinal contents below the last sacral root to be severed, should eliminate all the usual sensory channels from the hind limbs. This was the procedure usually carried out in the experiments to be described. As an aid to location of the roots the faradic current was occasionally used, although the posterior spine of the blade of the ilium on a level with the first sacral vertebra was an efficient anatomical landmark.

EXPERIMENT 1.—Rabbit. Lumbosacral laminectomy, section of 4th, 5th, 6th, and 7th lumbar, and 1st sacral posterior roots, left side.

Result.—The animal was considerably shocked. On examination the next day, the left leg was found to be completely paralysed. Stimulus applied to plantar and dorsal surfaces of the foot, and extensor and flexor side of the leg, was readily appreciated. On post-mortem examination it was impossible to decide whether the lower posterior roots had been severed owing to matting of the tissues. An extensive intrathecal hæmorrhage accounted for the paralysis.

EXPERIMENT 2.—Rabbit. Lumbosacral laminectomy. Section of the left 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots, and transverse section of spinal contents below 2nd sacral.

Result.—No paralysis of the left leg. Retention of deep sensation on the plantar and dorsal surfaces of the foot and on the flexor and extensor sides of the leg and

thigh. Stimulation of the leg evoked firm adduction. Sensation was most apparent between the first and second toes and over the sciatic nerve in the thigh. The skin was completely insensitive. Post-mortem: root division confirmed.

EXPERIMENT 3.—Rabbit. Lumbosacral laminectomy. Section of the left 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots, and transverse section of the spinal contents below 2nd sacral.

Result.—The left foot was completely paralysed, the leg nearly so, and the thigh showed marked paresis. The left foot was absolutely anæsthetic to all stimuli. Excitation of the leg produced an attitude of 'awareness', the animal turning round to look at the leg on some occasions. If its attention were diverted to the opposite side by holding a carrot there, stimulation would make it 'listen', then turn to look at the side stimulated. The thigh was also definitely sensitive to severe pinch-prick stimulus. The skin was everywhere insensitive. Post-mortem: root section confirmed.

EXPERIMENT 4.—Rabbit. Division of the left 4th lumbar to 2nd sacral posterior roots, and transverse section of spinal contents below 2nd sacral roots.

Result.—Total anæsthesia of the left leg. Slight paresis in muscles of left thigh.

EXPERIMENT 5.—Rabbit. Division of left 4th lumbar to 2nd sacral posterior roots, and transverse section of spinal contents below 2nd sacral roots.

Result.—Total anæsthesia of the left leg. Paresis of left leg.

The foregoing experiments demonstrated that in a certain proportion of cases sensation is retained in the deep structures after extensive posterior rhizotomy, whereas in all cases the skin is totally insensitive, results which bear comparison with those following the operation in certain human subjects. Again, it will be noted that no sensation was found in that part of a limb if it were paralysed, except in the first experiment. These results, when taken generally, indicate ventral root conduction, although the possibility of some additional path, such as the abdominal sympathetic conveying stimuli to a level above the root section, is not entirely excluded. The two following experiments eliminated this latter possibility:—

EXPERIMENT 1.—Rabbit. Laminectomy. Total transverse section of the mid-lumbar spinal cord above the 4th lumbar roots.

Result.—Complete paralysis and anæsthesia to all stimuli of both hind limbs.

EXPERIMENT 2.—Rabbit. Lumbosacral laminectomy. Section of 5th, 6th, 7th lumbar, 1st and 2nd sacral left posterior roots, and division of the spinal contents below the 2nd sacral root. There was almost continuous hæmorrhage from the cut laminæ, which was controlled by direct pressure; as a result the ventral roots were found to be damaged, and consequently all were finally divided.

Result.—Complete paralysis and anæsthesia of the affected leg. Post-mortem: root section confirmed.

These two experiments justify the conclusion that when sensation is retained after dorsal rhizotomy, it is mediated by the ventral roots below the 3rd lumbar roots.

The next question that presents itself is that of the intraspinal path of these impulses. In order to investigate this problem, posterior rhizotomy was combined with hemisection of the cord at the cephalic extremity of the wound (*Fig.* 355). All testing was carried out the day following operation and on succeeding days. The average period of survival was three to four days.

EXPERIMENT 1.—Rabbit. Lumbosacral laminectomy. Section of the 4th, 5th, 6th, and 7th lumbar, and 1st and 2nd sacral posterior roots, on the left side.

Transverse section of spinal contents below the 2nd sacral, and right hemisection of the cord at the head end of the wound.

Result.—Intrathecal hæmorrhage paralysed the left leg almost completely. Sensation absolutely lost in the left leg, and responses very weak from the right side.

EXPERIMENT 2.—Rabbit. Lumbosacral laminectomy. Section of the 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots, on the left side. Transverse section of spinal contents below the 2nd sacral root, and left hemisection of the cord.

Result.—Paralysis of left leg, paresis of the right leg. Cutaneous sensation lost on the left leg, but deep stimulation, especially of muscle and tendon, produced a definite sensory response. Post-mortem: root and spinal section confirmed.

EXPERIMENT 3.—Rabbit. Lumbosacral laminectomy. Section of the 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots on the left side. Transverse section of the spinal contents below the 2nd sacral root. Right hemisection of the spinal cord.

Result.—Paralysis of right leg, paresis of the left. Deep pressure stimuli were readily appreciated in the left leg. Post-mortem: root and spinal section confirmed.

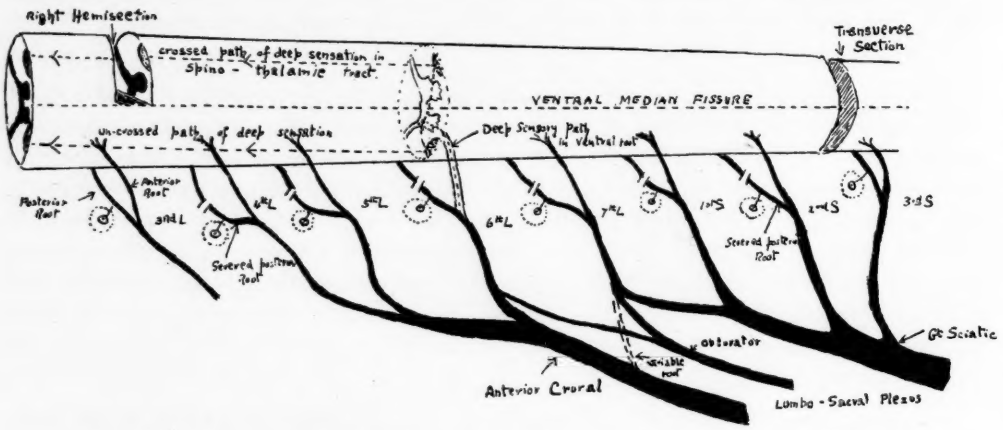

FIG. 355.—Diagram of lumbosacral cord, showing section of the 4th, 5th, 6th, and 7th lumbar and 1st and 2nd sacral posterior roots, together with transverse section of the spinal cord below the 2nd sacral roots, and right hemisection at the cephalic end of the wound.

EXPERIMENT 4.—Rabbit. Lumbosacral laminectomy. Section of the left 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots. Left hemisection of the cord. Much hæmorrhage.

Result.—Complete paralysis and anæsthesia of both hind limbs.

EXPERIMENT 5.—In the animal of Experiment No. 2 the right posterior column was divided on a level with the left; hemisection two days after the first operation.

Result.—Sensation in muscle and tendon was still distinctly appreciated: proving that the sensory impulses from these structures were traversing the crossed antero-lateral column, presumably in the spinothalamic tract. Post-mortem: root and spinal section confirmed.

EXPERIMENT 6.—Rabbit. Left posterior rhizotomy, hemisection of the cord, and division of the right posterior column as in Experiment No. 5.

Result.—Retention of deep sensitivity in the left leg. Right leg anæsthetic. Post-mortem: root and spinal section confirmed.

EXPERIMENT 7.—Rabbit. Lumbosacral laminectomy, posterior rhizotomy of the left 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral roots. Section of spinal

contents below 2nd sacral. Left hemisection at cephalic end of the wound. Section of right posterior column at the same level.

Result.—Severe pinch-prick stimulus applied to the point of the heel, the plantar surface of the foot, the flexor muscles of the leg and thigh, or pressure on the tibia, produced a definite sensory response half an hour after recovery from the anæsthetic. Examination on the day following showed complete loss of all sensation in the same limb.

EXPERIMENT 8.—Rabbit. Lumbosacral laminectomy. Posterior rhizotomy of the 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral roots, on the left. Section of spinal contents below the 2nd sacral. Left hemisection and division of the right anterolateral column.

Result.—Total loss of sensation in the left leg.

EXPERIMENT 9.—Rabbit. Lumbosacral laminectomy. Section of 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots, on the right side. Right hemisection of the cord, division of the left anterolateral column at the same level, and transverse section of all spinal contents below the 2nd sacral nerve.

Result.—Complete anæsthesia of both legs.

To summarize briefly the results of these experiments, it has been shown that :—

1. Complete transverse section of the lumbar cord above the 4th root abolishes sensation of the corresponding leg.

2. Section of all the roots of the lumbosacral plexus abolishes all sensation of the corresponding limb.

3. Section of the 4th, 5th, 6th, 7th lumbar, and 1st and 2nd sacral posterior roots, with transverse section of all below the 2nd sacral roots, results in retention of deep sensation in all parts of the corresponding limb, more especially in the leg and thigh in a certain proportion of cases.

4. Paralysis of any segment of a limb under conditions No. 3 removes the residual sensation.

5. The retained sensation gives rise to an attitude of 'awareness' rather than pain, although in one or two cases there appeared to be pain on very strong stimulation, but the response might be due to fear.

6. Section of the contralateral or the homolateral half of the cord, after rhizotomy as above, does not abolish the residual sensation.

7. Section of the homolateral or the contralateral side of the cord, with rhizotomy and division of the opposite posterior columns, does not abolish the residual sensation.

8. Section of the contralateral or the homolateral side of the cord, with rhizotomy and division of the opposite anterolateral column, entirely eradicates all residual sensation.

9. There were four negative cases where posterior rhizotomy abolished deep sensation.

10. The operative mortality averaged 28 per cent in all experiments.

Certain results of posterior rhizotomy as described by Trendelenburg in 1906 throw a corroborative light on the foregoing experiments. Working on pigeons, he noticed that when the dorsal roots were severed in those segments supplying the leg muscles, the tone of the latter was abolished; a destruction of similar roots in association with the wing muscles did not result in loss of tone ; the wings were retained in approximately their normal

position of flexion. Further, destruction of the labyrinth or removal of the brain did not abolish this tonic flexion. Baglioni, in 1907, explained the results as being brought about by a reflex excited through the leg muscles; it would appear equally explainable on the grounds of afferent fibres in the ventral roots mediating the sensory side of the reflex arc whose efferent side was also conveyed by the same, the phenomenon being dependent on a localized spinal reflex. Merzbacher noted similar facts in relation to the tone of the tail muscles in dogs.

EVIDENCE AS TO AN ENDONEURAL AFFERENT SYSTEM AS SHOWN BY THE CRANIAL NERVES.

Many important facts in connection with these nerves have been observed that throw considerable light on the question of an endoneural afferent system, which makes their discussion a vital point in the chain of evidence.

In the first place, the trigeminal, as the great sensory path of the face, may be considered. Cryer, of Philadelphia, reported three cases of neuralgic pain in the floor of the mouth which were studied by Ivy and Johnson. The pain was felt on the inner side of the lower jaw. Section of the mandibular division of the 5th nerve below the origin of its mylohyoid branch failed to relieve this condition, whereas section of the same nerve above this branch cured the pain, which was interpretated as showing that the motor mylohyoid nerve contains afferent fibres from the muscle, pain being seated in that structure. The same investigators studied a case of Spiller's where the latter had performed gasserianectomy for trigeminal neuralgia, in which they found complete retention of deep pressure sensitivity in the 5th nerve area, again pointing to the motor root of the 5th or the facial nerve as the conductor of deep sensation.

A case reported by T. H. Weisenberg and cited by L. Kidd introduces excellent clinical evidence to show that the central end of a severed 5th nerve possesses undegenerated afferent fibres. The patient suffered from typical trigeminal neuralgia in the distribution of the superior maxillary division, which was not relieved by five peripheral operations. Finally, gasserianectomy was performed; both motor and sensory roots were divided. Relief was only temporary; within a few months (cf. spinal cases) the pain returned in the lower part of the face, throat, and tongue, accompanied by paræsthesia of the oral cavity. The patient subsequently died, and at the autopsy a tumour of the cerebellopontine angle was discovered. This lay immediately on the sensory and motor roots of the 5th nerve. Microscopical examination showed that the cells of the mesencephalic root were normal, whilst section of the nerve showed regeneration in the motor root, with distinct myelin-sheathed axis cylinders amongst the numerous degenerated fibres in the sensory root. Kidd interprets this case as showing that the mesencephalic root is sensory; consequently gasserianectomy would cause degeneration of all the sensory fibres except those arising from this nucleus (that of the mesencephalic root) which pass out either in the sensory or the motor roots of the 5th. With respect to the latter, Aldren Turner, in 1894, found in an eight-month human fœtus that

all the medullated fibres of the mesencephalic root traversed the motor division. Thus the tumour in Weisenberg's case would stimulate the undegenerated afferents, the irritation being referred by the cortex to the peripheral distribution.

This interpretation of the cells of the locus cæruleus and the tectum mesencephali which gives rise to the mesencephalic root is supported from other considerations. These cells develop from the dorsal lamina of His, which is not known to give rise to any motor cells. Johnston compares them with the dorsal cells found in the spinal cord of fishes and amphibians, which belong to the same category as the peripheral ganglion cells, whilst they may also be compared with the ganglion cells of the dorsal nerves in the amphioxus, many of which lie within the central nerve cord. All of which points indicate the afferent function of this root of the 5th nerve.

Miss Tozer and Sherrington, in a series of experiments on the ocular nerves, found that section of the 3rd, 4th, and 6th at their central origin caused a disappearance in the eye muscles, not only of the motor end plates, but also of the sensorial terminals. Sherrington had previously shown in 1898 that these sensory fibres in the ocular muscle do not degenerate after gasserianectomy, proving that they possess trophic cells situated either in the central nervous system or amongst the root fibres, the afferent axons of which run in association with the motor fibres.

The presence of afferent fibres in the facial nerve of animals was long ago shown by the stimulation experiments of Bernard, where irritation of the central end of the severed nerve resulted in " une sensibilité évidente " or " le bout central était très sensible ". In 1899 Aldren Turner cut intracranially this nerve in *Macacus rhesus* for Edgeworth, who examined the branch to the posterior belly of the digastric, which showed complete degeneration with the exception of three medullated fibres all under 4 μ in diameter; on the other hand, the main trunk of the facial peripheral to this branch showed non-degenerated fibres from 11 to 12 μ in diameter. The larger fibres may be compared with those which Gaskell and Edgeworth describe in association with the spinal roots, and which average about 7 to 9 μ in diameter in the dog, and which they consider sensory in function. Their presence in the facial is made clearer in the light of Amabilino's findings—that section of the chorda tympani produces degeneration in only two-fifths of the cells in the geniculate ganglion.

Turning to the clinical side, Kidd states that in his experience 75 per cent of cases of facial palsy exhibit sensory disturbance. Lastly, the evidence of gasserianectomy shows that vague deep sensation is retained in many cases on strong compression of the facial muscles against the bone, in addition to the case of Spiller's already mentioned; whilst the remarkable diminution of the anæsthetic field following this operation, after a lapse of years, must be borne in mind.

Finally, the case for the dorsal vagoglossopharyngeal nucleus may be cited. Hudovernig found changes in the cells of this nucleus in a case of carcinoma of the œsophagus, illustrating the 'distance reaction' following the reception of afferent irritant stimuli by the cells, which would not occur if a synapse were interpolated on the path between œsophagus and dorsal nucleus; from

which it follows that the afferent trophic cells of the fibres concerned may be endoneural in situation.

From this conspectus of the evidence derivable from the cranial nerves bearing on the question of an endoneural afferent system, three general inferences may be made:—

1. That the 5th cranial nerve contains afferent fibres possessing centrally situated trophic cells, the axons of which run partly with the motor fibres.

2. That the same is possibly true of the dorsal vagoglossopharyngeal nucleus, whilst the facial nerve is probably an example of the association of muscular afferent and the corresponding motor fibres.

3. That sensation mediated by these afferent nerves from muscle is very difficult to elicit by ordinary stimulus.

4. That the 3rd, 4th, and 6th ocular nerves contain afferent muscle fibres associated with the motor supply which possess trophic cells in the central nervous system or in the nerve-roots.

CONCLUSIONS AS TO SENSORY CONDUCTION IN VENTRAL ROOTS.

In concluding this section bearing on the mediation of afferent stimuli by the anterior roots, the evidence from the different sources may be summarized.

1. From the experimental side, despite the difficulties of interpreting sensory responses in animals, and allowing for fallacies and negative results, there would appear to be reasonable grounds for the belief that rabbits receive afferent impulses from the deep tissues, such as fascia, muscle, tendon, and bone, by the ventral roots. The work of Claude Bernard on anterior-root sensibility demonstrated that sensory effects follow stimulation of the same, of which it is possible that the minor sensory responses are due to centripetal fibres in these structures. Again, from the experimental side the results of Trendelenburg's experiments on pigeons probably depend on ventral-root sensory fibres completing the tonic reflex arc.

2. From the clinical side, the cases of dorsal rhizotomy for tabes crises and cervicodorsal rhizotomies for brachial neuralgias followed by retention of deep sensation, and also those cases which show a rapid return of sensation after root resection, emphatically point to the existence of a sensory channel in addition to that through the posterior roots. Similarly, from the subjective standpoint the return of pain in many of these cases indicates a like proposition. Finally, the case of rhizotomy for tabes with ventral-root section already described, which showed complete anæsthesia and cure, taken in conjunction with a successful case of cervicodorsal rhizotomy of both roots for intractable stump neuralgia, greatly strengthens the sensory ventral-root hypothesis.

3. The third field, which supplies us with strong collateral evidence, is that of the cranial nerves, where it was shown that there was reason to believe that an endoneural afferent system exists; centripetal impulses from muscle being conveyed by axons possessing centrally situated trophic cells, the same entering the nervous system in association with the motor fibres.

From these three general lines of evidence we feel justified in concluding that the anterior spinal roots mediate afferent impulses in normal individuals from deep tissues.

THE CONDUCTING MECHANISM.

The nervous pathways by which these pain stimuli are conveyed to the spinal cord must now be discussed, more especially with reference to the physiological types of fibres involved.

For convenience of analysis, the varieties of pain will be considered in three broadly-defined groups according to whether there is: (1) *Vascular dilatation*; (2) *Vascular constriction*; or (3) *Neither of these phenomena.* But it must be remembered that in actual practice the same case may exhibit all three varieties at different stages, or combinations of these effects.

Group 1.—The first group comprises those cases that show the typical causalgic syndrome. Pain of a burning, throbbing, prickling, or bursting character is complained of: persistent in form, and accompanied by dilatation of the blood-vessels, with consequent erythema and slight swelling of the affected part.

As pointed out by Professor J. S. B. Stopford (in a paper in the *Lancet*, Aug. 11, 1917, on a series of cases of thermalgia), vasomotor disturbance of a dilator type is the principal pain factor in these cases. At the same time he suggests that the vasodilator phenomena are reflex in character; otherwise one would have to suppose a selective action of the intraneural sclerosis on the depressor fibres, which would be difficult to understand, whilst the same investigator makes the supposition that irritation would produce a depressor effect as a "protective and defensive mechanism".

If these vasodilator phenomena are dependent on a depressor reflex, what are the components of the reflex arc?

To comprehend the subject thoroughly it is necessary to turn to the surgical procedures that have been practised for the condition. Local resection of the scar tissue of the partially divided nerves, with secondary suture, completely cured many of these cases due to gunshot injury. Microscopical examination of the resected nerves commonly showed extensive intraneural fibrosis. From these results we might conclude that the primary form of irritation is in the injured nerve; hence resection of the same cures the condition. The other procedure, carried out by R. Leriche, of Lyons, is peri-arterial sympathectomy. In a series of cases of causalgia this operation cured five and improved two, the remaining two being failures; whilst Platon met with success from this *modus operandi* in 75 per cent of his cases: results which show that roughly three-quarters of these causalgic neuralgias are benefited by sympathectomy.

If the sensory path to the central nervous system by which the throbbing pains are perceived lay in ordinary sensory fibres, peri-arterial sympathectomy could not possibly interfere with their conduction. Thus, if the artery were denuded, the irritation from the nerve lesion would still be perceived by the sensory fibres in the mixed nerve which terminate in cutaneous and deep receptors.

This raises the question as to whether vascular dilatation is the essential cause of the burning pain, or is this an independent and superadded feature to the vascular depression? That the latter is indicated is shown by the results of peri-arterial sympathectomy—a procedure which first results in

arterial spasm, and secondly in considerable vascular dilatation and hyperæmia of the skin. At the same time the typical pain is cured.

Again, in some cases of causalgia it is well recognized that the case may change in respect to the vascular symptoms, signs of constriction of the vessels following after prolonged dilatation; nevertheless in these cases pain still persists, losing only its thermal character, that is, the burning sensation. The course of the peri-arterial fibres which convey the pain sense, above described, was shown to a certain extent by an experiment which Professor Stopford kindly performed for me. The two possible channels by which such fibres might conceivably reach their destination are either through a mixed nerve passing into the peri-arterial plexus at intervals throughout the course of nerve and artery down the limb, or by joining the blood-vessel soon after leaving their origin and following its entire length. In the experiment mentioned, the sciatic nerve was divided in the gluteal region of a rabbit. Testing for sensation demonstrated its presence in the foot, especially on the dorsum between the first and second toes. The internal saphenous nerve was now severed, and the foot was found to be totally anæsthetic to all forms of stimulation, showing that there were no afferent fibres following, for example, the dorsalis pedis artery and proceeding up the vessel to a proximal source independent of the main nerve, thereby suggesting that they probably arise at intervals from the mixed nerve to join the artery, similarly to the supply of the phalangeal joints by the digital nerves.

From this it will be seen that section of the sympathetic on an artery at the proximal end of a limb for a peripheral disturbance would not interrupt stimuli traversing the lower arterial twigs of the mixed nerve, which would account for the cases of failure after this operation.

Returning to the question of reflex origin of the vascular phenomena, we have to consider the spinal roots by which the stimuli reach the central nervous system. In view of Bayliss's work upon the condition of vasodilator fibres in the posterior roots, the latter suggest themselves both on this consideration and as their being general conductors of centripetal impulses. It has been shown that the pain is distinct from the vascular dilatation, and that both are probably mediated by the peri-arterial plexuses. A case of Sir William Thorburn's exemplified very clearly this difference between pain and dilatation, at the same time indicating the path of approach to the spinal cord of the pain impulses:—

The patient sustained a bullet wound in 1914, and examination in 1915 showed a partial paralysis of the upper limb, accompanied by patchy analgesia and hypoæsthesia to cotton-wool touch; in addition to these objective signs he complained of a tingling burning pain localized to the palm of the hand and to the centre of the forearm for about a third of the distance to the elbow-joint. At the first operation the inner side of the median and the ulnar nerves were sutured. The causalgia persisted, and at a second operation neurolysis was performed, which greatly aggravated the condition. On re-examination in 1921, trophic changes were evident, the skin of the hand was thin and glossy, the nails long and curved, whilst the intrinsic muscles of the hand showed extreme wasting. About this period the thermal symptoms—that is to say, the burning sensation and the vasodilatation—subsided, the pain persisting as a constant gnawing ache, whilst the hand became withered in appearance. Posterior rhizotomy of the 6th cervical to the 1st dorsal roots was performed, and they were seen to be clearly divided. The day following operation there was

an exacerbation of pain, which subsided on the second day, after which the former pain (aching) returned in the same area of the hand, and is still severe at the present day.

In this case it is clear that all afferent paths via the dorsal roots have been interrupted from the affected areas, leaving the ventral roots as the possible channel for sensory conduction of the pain stimuli. (The question of intraspinal irritation is discussed later.) Were the earlier vasodilatatory phenomena dependent on a reflex the afferent side of which was mediated by the ventral roots ? Do the persistent pain impulses still traverse this channel ? These are the pertinent questions suggested by this case.

Gaskell has shown that stimulation of the anterior roots of the sciatic plexus causes an increased blood-flow through the muscles of the leg, indicating that depressor fibres exist in these roots. The presence of depressor fibres in the ventral cervical roots is therefore a possibility. Bayliss has shown that the efferent depressor stimuli traverse the posterior roots, the impulses being conducted by fibres possessing trophic cells in the posterior root ganglia and consequently indistinguishable anatomically from the normal sensory fibres—a fact which suggests that these efferent impulses are conducted antidromically to the ordinary stimuli in the posterior root fibres. This possibility is further shown by the effects of mustard oil applied to the skin, the stimuli from the oil causing reflex vasodilatation, an effect which is still produced after posterior root section until degeneration has spread to the peripheral parts of the fibres involving the collateral branches to the blood-vessels in association with the area of skin supplied by the affected fibre. The stimuli in this case must pass in an afferent direction up the sensory fibre and down the nearest collateral to the blood-vessels. Since the mediation of depressor impulses by afferent fibres is known to exist, it seems reasonable to suppose that the converse might equally pertain, namely, the conduction of sensory stimuli by depressor efferents traversing the ventral roots, especially when we consider that the fibres conveying these causalgic pains are associated with the nerves to the blood-vessels, as already shown.

The failure of posterior rhizotomy then becomes easily comprehensible. Even supposing the vascular dilatation observed in these cases to be the result of an axon reflex, or, again, of a reflex produced through the undisturbed posterior root ganglia, there still remains to be explained the path of the pain sensation to the spinal cord when the dorsal roots have been severed, with consequent complete degeneration in the ascending tracts of their fibres.

Another very interesting case which may be considered at this juncture is one reported by Professor Stopford :—

The patient was wounded in 1918 by a bullet in the neck, resulting in complete loss of power in the left arm, and within a week in the onset of severe burning pain in the thumb. Examination in July of the same year revealed complete paralysis of spinati, with great paresis of the deltoid, biceps, brachialis anticus, triceps, and supinator longus, but no objective sensory disturbance could be found ; on the other hand, there was severe burning pain in the thumb, aggravated by heat ; all of which symptoms abated in time.

In this case the complete absence of sensory disturbance would seem to negative any injury to the sensory root fibres, the subjective disturbance, of

a typically causalgic type, being associated with the motor lesion: again strongly suggesting the irritation of afferent fibres in these roots, which also resulted in depressor effects on the blood-vessels.

It is worth recalling at this juncture that the sensory end organs such as the Pacinian bodies and those of Ruffini possess very vascular networks. From the results given above, there appears to be a strong suggestion of some relationship between sensation and vascular dilatation which is independent of the usual sensory nerves, and at the same time there is an independence between the sensory element and mere dilatation of the vessels, the one being capable of existence without its complement: the two together, vasodilatation and irritation of afferent fibres, producing the typical burning pain; but without the depressor action, pain is only gnawing or aching in character. As for the cause of the change in some of the causalgias to vasoconstriction, Professor Stopford has suggested that it is due to local trophic disturbances in the blood-vessels causing proliferation of the intima resulting in occlusion or partial occlusion of the vessels. The association between sensory receptors and vasodilatation is further illustrated by the results of a series of experiments I carried out on the human subject, from which one made the general inference that stimulation of a mixed nerve so as to produce vascular depression also results in diminution of the threshold stimulus in both deep and cutaneous receptors; a result which is independent of passive flushing due to the dilatation of the blood-vessels in the sensory organs, whilst at the same time it is not attributable to simple hyperæsthesia of ordinary afferent fibres—suggesting that the nerves that convey depressor impulses also augment sensory receptivity, which when applied to these cases explains the relation of peri-arterial sympathectomy in the alleviation of pain.

Group 2.—In the second group will be discussed the nervous paths of those forms of pain which are associated with pressor effects in the vascular system, and other signs of sympathetic irritation, such as persistent hyperidrosis of the painful area, or rapid rise of blood-pressure concomitant with a pain crisis.

This group may be subdivided into three distinct types: (*a*) Pains of a lightning or stabbing character; (*b*) Pains described as gnawing, aching, or burning; (*c*) Griping, twisting or vice-like pain, generally occurring only during acute crises. The distinctions of this group from the former are the entire absence of vasodilator signs and thermalgic character of the pain; on the other hand, the areas affected frequently show vasoconstriction, or if these symptoms are intermittent, they generally occur during an acute exacerbation. Lastly, at the risk of repetition, it must be remembered that these several varieties may occur together or independently in the same individual.

a. The lightning stabbing form of pain so often seen accompanying tabetic lesions is generally cured by section of the posterior spinal roots, which proves that its mediation is dependent on afferent fibres traversing the general sensory path. Thus, in a case of Hey Groves's in which there was persistent neuralgia of this type in the legs, the left more especially, posterior rhizotomy, although failing to cure the pain, changed its character, which after operation was described by the patient as being like a gnawing sensation; at the same

time its severity was somewhat mitigated. Likewise, I have noted that the lightning radiating pain in the body wall which occurs in gastric crises is abolished by the root resection.

b. The second variety, which is gnawing in character, frequently accompanies the lightning type, persisting between the exacerbations of the latter. In addition, the peculiarity of its situation is sometimes recognized by the patient, who states that it feels as if it were in the 'flesh'; others describe it as being in the 'bones', discriminating it from a superficial hyperæsthesia. This situation of the pain was clearly shown in two of Thorburn's cases (tabes dorsalis crises), where deep sensibility was retained after rhizotomy. In both, the somatic pain complained of was of a dull, gnawing character, located in the deep tissues of the abdominal wall, clearly differentiated from a deeper intra-abdominal pain which was only experienced during a crisis, and equally differentiated from the skin by the patient, who always described it as being a 'muscular sensation'. In its severer form the onset of this pain was accompanied by marked increase of sensitivity of the deep tissue to light pressure stimuli. This variety of pain merges during an acute crisis by imperceptible degrees into

c. The third type, that which is characterized by a griping or twisting sensation. One of the two cases referred to described the deep sensation as a feeling as if the muscles were being tightly twisted; a vice-like grip was also complained of.

Accompanying these subjective sensations there are frequently seen signs of sympathetic activity, such as vasoconstriction and rapid rise of the blood-pressure—in one of the above cases from 130 mm. Hg to 175 mm. Hg—whilst in the same patient reduction of the blood-pressure by trinitrin tablets and amyl nitrite to 85 mm. Hg abolished this symptom. Another fact pointing to the sympathetic associations of this type of pain is its excitation by adrenalin injection, the subcutaneous injection of this drug (10 min. 1–1000 solution) producing an acute crisis in one of the tabes cases, whilst a case reported by Barling showed an increased pulse-rate to 120 per minute.

It has been shown that this dull type of pain is principally located in the deep structures, especially in muscle. The griping character occasionally assumed by the pain is essentially characteristic of muscular disturbance, whether splanchnic or somatic, and does not feature in cutaneous hyperæsthesias or in bone pains. All results of experimentation go to show that muscle sense is most difficult to evoke by ordinary stimuli; but when produced by pathological irritation it is capable of giving rise to most exquisite pain, as, for example, in an intestinal colic or a cramp of the calf muscles.

As already stated, the muscle afferents from the eye are not affected by gasserianectomy; nevertheless the eye may be excised after the latter operation without any sensation being felt by the patient (*see* Morriston Davies), although Sherrington has stimulated the inferior oblique muscle of a cat's eye, with consequent pricking of the ears and movement of the opposite eye, as if it appreciated some sensation. Again, the results of sensory experiments on the alimentary canal show that only slight sensation is produced by the strongest stretching or pinching of the muscle coat of the bowel, which is totally irresponsive to cutting stimuli, though a sensation of definite

discomfort may be elicited by inflation of a localized segment (e.g., colostomy). Myological sense may be said to possess a high potential which can only be evoked by a morbid process.

We have, therefore, to investigate the nerve path of these painful muscle stimuli. If cervicodorsal posterior rhizotomy alone failed, it would be reasonable to presume that the afferent path of the stimuli lay through the sympathetic connection traversing the first dorsal ganglia to the lateral chain, and thence via the posterior and lower dorsal roots to the cord. The failure, however, of extensive and even bilateral posterior rhizotomy of the dorsal roots for epigastric pains, as in tabes, where there is no intricacy of the sympathetic path as pertains in their distribution to the upper limb, eliminates this possibility, and indicates once more the ventral roots as the mediators of the sensory stimuli.

What structures are there to be found in muscle which can be definitely associated with the sympathetic system, which communicate with the spinal cord by the ventral roots, and where function has not been proved to be either motor or propriceptive? The terminals described by Boeke and Agduhr fulfil these conditions. They consist of non-myelinated fibres terminating in cluster-like ramifications beneath the sarcolemma, often in close apposition to, or even in conjunction with, the motor end-plates, whilst Agduhr has observed them on the fibres in the muscle spindles. Thus from their situation and histological appearance the evidence as to function is equivocal. Their sympathetic nature has been definitely demonstrated by section of the anterior and posterior roots of the 5th, 6th, 7th, 8th cervical and the 1st dorsal nerves, and extirpation of the posterior root ganglia, which does not produce degeneration of these endings in the interossei muscles similar to all the myelinated endings; whilst, on the other hand, removal of the stellate ganglia results in their degeneration. Similarly, section of anterior and posterior roots with excision of their ganglion in the dorsal region also leave untouched these terminals in the intercostal muscles, showing that the trophic cells of the peripheral fibres must be in the sympathetic ganglia of the lateral chain, the spinal connection being in all probability through the ventral roots by the white rami communicantes.

It has been suggested that their function is the mediation of trophic stimuli, or to assist in the preservation of muscle tone. As to the latter, the evidence appears contradictory, although on this theory the results of Trendelenburg's experiments are quite intelligible, these sympathetic fibres acting as afferents in the tonic reflex arc.

In one of the tabes cases previously cited, where an experimental injection of adrenalin was administered, the rigidity of the skeletal muscles in the painful area was so very pronounced a feature as to produce opisthonotus accompanied by a pain in the posterior muscles of the spinal column described as being like the 'grip of a vice', which passed off as the muscular contraction subsided. A similar type of rigidity has been noted to accompany the 'stupeur artérielle' of Leriche. This observer has seen motor contraction diminish and disappear when 'acting on the peri-arterial sympathetics'; he also mentions a case of Clovis Vincent's where even deep general narcosis and section of the main nerves in a case of painful stump failed to relieve

painful muscular rigidity, whereas sympathectomy immediately relieved both symptoms, which had not reappeared after forty days. He states that he and Heitz have seen sympathectomy greatly improve eighteen cases of hypertonic contraction, which subsided the day following operation.

These observations emphatically point to the deep-seated pain of a definitely gnawing character, often associated with muscle rigidity, as being mediated by the sympathetic supply to deep tissues, especially the muscles. In this connection it is interesting to mention some observations recorded by Beer on a case where he divided the left anterolateral tract of the spinal cord for a neoplasm causing right-sided neuralgia in the leg. After operation, which abolished pain, he noticed that there was diminution to pressure sensibility of the muscles on the right side which was associated with complete analgesia in the same area, suggesting that the pain in this case was mediated by tracks possibly in part association with deep pressure impulses. It will be recalled that in the rabbit experiments the deep retained sensation was found to be conducted principally by the anterolateral tracts, evidently associated with the impulses of pain.

Group 3.—In the third and last group are placed those pains which are not accompanied by any marked vasomotor disturbances. The operative results suggest that some of these cases may be due to irritation solely confined to afferent fibres traversing the posterior roots; consequently section of the root corresponding to the affected area cures the condition. Two patients of Bennet's and another of Horsley's exemplify the operative results in these cases. They are not, however, typical of the large majority of neuralgic cases that fail to subside with medicinal treatment or peripheral operations.

The close similarity of many of these pain cases to those associated with definite sympathetic disturbance suggests that they are dependent upon a similar nervous channel. The deep tissue seat of some and the failure of posterior root section in others both indicate the affinity between the simple forms and those with obvious vasomotor symptoms.

Finally, it will be seen that a diffuse lesion such as occurs in tabes may irritate more than one type of nerve path in the same individual; consequently burning pain may be felt in one area, whilst aching and griping sensations occur in another in association with vasoconstriction.

In concluding this section on the pain conduction, the evidence showing that the sympathetic system probably mediates these stimuli especially from muscle may be reviewed, namely that :—

1. Pain in these cases is principally seated in deep tissues.

2. The rigidity in the tabes case clearly points to a muscular origin of pain.

3. Sweating, vasoconstriction, raised blood-pressure during pain crises, rigidity of muscle in a pain crisis, tachycardia, and adrenalin hypersensitivity also indicated an irritability of the sympathetic system.

4. Sympathectomy abolishes painful muscle spasm.

5. The end organs of Boeke supply the necessary sympathetic terminals for the location of these phenomena in muscle in association with that system,

and the central connections of these end organs explains the many partial or complete failures of posterior rhizotomy.

INTRASPINAL IRRITATION.

The last possible cause of pain in cases where posterior rhizotomy has failed is intraspinal irritation.

It is reasonably conceivable that the effects of a rachniditis would not be confined to the spinal roots but extend to the columns of the cord; in such cases the intraspinal irritation might bring about the failure of the extraspinal operation. Secondary sclerosis might produce thermalgic pain, as occasionally it does in cases of disseminated sclerosis. On the other hand, it will be remembered that the majority of these neuralgias exhibit a strictly localized distribution within a definite area, generally involving one or two spinal segments which, if we are to suppose intraspinal irritation, would necessitate an irritant stimulus confined to these fibres in association with the affected area. If the posterior roots concerned are severed, then the irritated fibres will completely degenerate, whilst the division of roots above and below those affected would entail complete degeneration of all neighbouring axons; from this one might reasonably expect relief of pain after the degeneration was complete—a result infrequently obtained. Such changes would not remove the source of irritation; for example, an area of chronic inflammation which would progress beyond its previous limits so as to involve normal tracts, which would result in a return of pain after a varying interval—a development that frequently occurs, but with this important difference: pain returns in the old area in most cases, not in neighbouring and healthy area, which would be the case if fresh axons were involved.

Lastly, the results of section of the anterolateral column for widely divergent cases of intractable pain strongly discountenance a spinal source of irritation: they will be reviewed in the next section.

THE SURGICAL INDICATIONS.

The ideal procedure would aim at the complete interruption of all nervous pathways conducting irritant stimuli to the brain; but this would depend upon whether the source of the irritant is situated in the peripheral nerves, in the spinal tracts, or in the higher cerebral centres. If the lesion were in the first named, obliteration of its channel of conduction ought to be possible. If in the spinal column, it is evident that a localized lesion anywhere below the origin of the roots of the phrenic nerve could be cut off from the higher centres by section of the tract affected; but, on the other hand, a diffuse lesion involving an entire sensory tract up to the brain stem could not be treated surgically without grave danger, whilst a purely cerebral source of irritation would be without the province of surgery.

From the general results of operative treatment for these pain conditions, and their clinical history, only a very small minority show a definite psychological factor. On the whole, the source of irritation would appear to be in the peripheral nerves, whilst the question of intraspinal stimulation has been

considered in the last section, where an attempt was made to show that relapse after rhizotomy from a lesion in this situation is improbable, at least after any considerable interval.

Accepting for the present the principle that peripheral irritation is the main factor in the majority of these cases, then by section of spinal roots we should be able to interrupt the afferent impulses, the question being, which roots to sever.

It has been shown, in connection with neuralgias of the brachial distribution, that the pathways affected probably depend on the type of manifestations, pain of a thermalgic type associated with the depressor effects being mediated by dorsal and ventral roots, but having no accessory path by the inferior cervical and first dorsal ganglia. In these cases rhizotomy of both ventral and dorsal roots would have to be practised in order completely to sever the afferent channel. The procedure would only be admissible for cases of causalgic neuralgia in post-operative stumps, when the resulting paralysis would not be of any consequence, and, as shown by past work, would relieve the motor spasm sometimes found to accompany the pain.

Again, in connection with the pain in the body area, we have shown that unilateral rhizotomy of both roots of the mid-dorsal segments is not attended by any respiratory embarrassment from the resulting paralysis of the intercostal muscles, although the after-effects would be dubious if the same procedure were performed bilaterally. In a strictly unilateral pain as in Thorburn's case, involving the mid-dorsal segments, one might reasonably consider anterior and posterior rhizotomy. On the other hand, the great difficulty in connection with root section is to ascertain that all the roots to the affected area of the cord have been severed, a small resection frequently failing, despite the previous localization of the symptoms, although this was probably due in the past to the ventral root mediation. Also the resection of many roots necessitates considerable exposure of the cord, with attendant shock.

Lastly, cases of very localized pain in peripheral areas occasionally yield to section of the roots of the area concerned. Here again there is a great difficulty in knowing whether the neuralgia purely affects the ordinary dorsal root fibres—an uncertainty which renders a localized rhizotomy useless in most cases.

In concluding the case for rhizotomy we have to weigh the following facts :—

1. In cases of stump neuralgia of the upper or lower limbs all ventral and dorsal roots should be severed, if the prognosis is to be at all favourable in all cases. This procedure will abolish intractable stump neuralgia of a thermalgic type; but there may be a residual pain due to sympathetic mediation, in which case, if the opportunity presents, where there has been a double cervicodorsal rhizotomy, the extirpation of the last cervical and the first dorsal sympathetic ganglia should be considered.

2. Posterior rhizotomy is occasionally successful for limb neuralgias, but the prognosis is completely uncertain.

3. In only rare cases is a localized rhizotomy for localized pain successful.

4. In tabes cases the considerable proportion of successes after posterior root section justify the operation in localized unilateral cases.

5. This should be accompanied by anterior rhizotomy.

6. The great disadvantage is the considerable exposure of the cord necessary for extensive root section, with consequent shock.

Turning to the second situation, where the pain stimuli may be intercepted, we have to consider the anterolateral column of the spinal cord. It has been shown that probably all pain impulses cross in the cord and ascend in the spinothalamic tract of the anterolateral column; therefore section of the same should completely intercept all such stimuli, providing the section is made above the lesion. We may briefly review the results of this operation. Spiller and Martin performed it on a man suffering from great pain in the lower limbs, the result of inoperable tumour of the spinal cord. Both tracts were severed, with great relief from all the former pain, although he still had slight discomfort at times: the possibility of a few fibres conveying the stimuli in the posterior columns must be admitted, or the incomplete severance of the tracts. Förster by this operation cured a case where dorsal rhizotomy had failed to abolish pain.

Beer in 1913 sectioned the left column for pain in the right leg secondary to neoplasm, with complete relief of the symptoms. Souttar cut the right column for painful gastric crises of tabes. The patient suffered from intense gastric crises, accompanied by pain in the left leg and left side of the body, with burning pain in the shoulder, and intense headache. The operation was performed at the interval between the 1st and 2nd dorsal roots, and resulted in complete abolition of pain with crossed analgesia of the left side of the body. The only relapse was a painless attack of vomiting. Lastly, I hear that a case of causalgia has been successfully treated by this method.

These results, coming from widely different sources, clearly bear out the principle of peripheral irritation, at the same time illustrating the efficiency of spinal section. The advantage of the procedure over rhizotomy is threefold. In the first place a very much smaller exposure is necessitated; and in the second place the pain fibres are concentrated within a very small area, and all afferent fibres mediating pain impulses can be severed with reasonable certainty. Finally, the operation does not involve paralysis if the crossed pyramidal tract be avoided—a sequel which must infallibly follow dual rhizotomy. All these features, we conclude, make this the operation of election in all cases of intractable neuralgia, whether in limb or body areas.

The only disadvantage would appear to be the delicacy of the procedure and the danger of paralysis, although even if the latter mishap should follow, as in Beer's case, the great sensory relief obtained far outweighs the motor loss.

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THE BACTERIOLOGICAL AND PATHOLOGICAL EXAMINATION OF THE VERMIFORM APPENDIX IN THE FIRST THIRTY HOURS OF ACUTE APPENDICITIS: WITH SPECIAL REFERENCE TO THE PRESENCE OF 'FATS' IN THE WALL OF THE APPENDIX AND LYMPHOID TISSUE.

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The appendix was removed in twenty-five cases in the early stages of the acute disease. From the clinical history the maximum period of illness was within thirty hours. It was believed that this stage of the illness was the ideal period for detailed investigation. Twenty-seven cases were examined, but in two instances, although the symptoms led to the clinical diagnosis of acute appendicitis, the viscus was found to be normal on examination in the laboratory. Ten control cases of chronic recurring appendicitis were also made use of, more especially for the study of 'fats' and for comparison with the changes in the acute stages of appendicitis.

METHOD OF INVESTIGATION.

All the preliminary investigations about to be referred to were made by one of us (P. H. M.) at some period of the abdominal operation.

Blood from one of the arm veins was taken from each patient at the time of operation. Several cubic centimetres of blood were added to the most appropriate media for the purpose, and the remainder was set aside for serological investigations. Urine was withdrawn by catheter. The peritoneal fluid was collected in a sterile tube for bacteriological examination when present in sufficient quantity. The appendix was removed by the usual method, and care was taken that it did not come in contact with the skin or abdominal parietes. It was placed at once in a sterile tube and sent to the laboratories for the detailed investigation about to be referred to.

The viscus was split with sterile scissors from base to apex, and portions of the wall were taken for microscopy. Concretions were removed, and ova were looked for in the depths of the mucosa with a hand lens. The contents of the appendix were spread on sterile unglazed tiles, and the dry residue was submitted to bacteriological investigation by the method introduced by one of us (L. S. D.). The mucosa was scraped with a blunt scalpel, the scraping was examined microscopically, and the remainder added to the material on the tiles obtained from the interior of the appendix. By these means, parasites or ova embedded in the appendix wall should not have been overlooked.

Blood Cultures.—As already stated, vein puncture was made by one of us (P. H. M.) on each occasion when the patient was under the anæsthetic. The skin was thoroughly cleaned with ether before the vein puncture was

attempted, and several cubic centimetres of blood were added to tubes of glucose broth, distilled water, and 2 per cent bile salt in distilled water.

In 11 out of the 13 positive results obtained, the bacteria were cultivated in the bile medium only; no growth occurred in glucose broth in 23 cases, nor in distilled water in 21 out of the total of 25 cases. In the bile medium *Staphylococcus albus* was obtained on 12 occasions, and *S. aureus* on 3. On clinical evidence all these 25 cases were in the early stages of acute appendicitis of thirty hours' duration or less. A streptococcus cultivated from the blood-stream in one case was non-hæmolytic and of the short-chained type. A massive growth of a similar streptococcus was obtained from the interior of the appendix, which was gangrenous.

The Urine.—A detailed examination of the urine was undertaken in 18 out of the 25 cases, because symptoms referred to the urinary system occur in acute appendicitis, and we wished to ascertain the relative frequency of *Bacillus coli* infection of the urinary tract in acute appendicitis. It is well known that acute coli infections of the urinary tract may be mistaken for appendicitis, and may occur subsequent to an attack of acute appendicitis.

The urine was withdrawn by catheter in every instance as a preliminary to the operation. *B. coli* was cultivated from the urine in three of the patients with acute peritonitis, and, although leucocytes were present in the urinary deposits in two of these cases, there was no true pus-formation. Mucus, and in one case a trace of blood, were also found. In the first of these cases, *B. coli* was not isolated from the acutely inflamed appendix, and the urinary culture of *B. coli* did not agglutinate with any of the anti-colon sera prepared by Dudgeon, Wordley, and Bawtree.* In the second case, *B. coli* was isolated from the pus in the appendix as well as from the urine, but the strains obtained from the two sources did not correspond on cultural evidence, and were inagglutinable with the anti-colon sera. In the third case, the *B. coli* obtained from the urine and peritoneal fluid corresponded serologically. In 7 instances the urine was sterile, in the remainder streptococci (4) and *S. albus* (5) were cultivated. Leucocytes were seen in 9 cases, blood and mucus in 10, traces of albumin and calcium oxalate in 3 cases.

Agglutination Reactions.—The patients' sera were tested with T.A.B. and C. antigens, with three hæmolytic, and three non-hæmolytic coli antigens as employed by Dudgeon, Wordley, and Bawtree. There was no evidence of a typhoid or paratyphoid infection in any of these cases; but two of the patients showed the presence of inoculation agglutinins, (1) 1–100, (2) 1–200, and in one case, a girl of 12, the typhoid end-point was 1–100, but no clinical or pathological evidence of typhoid fever could be obtained. No reaction was obtained with two of the hæmolytic coli antigens (1–50), but in two cases a reaction of 1–100 was obtained with the third hæmolytic coli antigen. Hæmolytic colon bacilli, however, were not cultivated from the interior of the appendix, peritoneal fluid, or urine in any case of this series.

Two cases reacted at 1–100 and one at 1–200 with one of the non-hæmolytic coli antigens, but no further reactions occurred with any of the three

* The anti-colon sera referred to throughout this paper are those prepared by these workers.

non-hæmolytic coli antigens employed. Colon bacilli, serologically similar, with the bacilli agglutinated, were not isolated from these three cases. We may again recall that the duration of the acute symptoms in these cases was limited to a period of thirty hours, so that the agglutinin content of the sera in the four cases referred to must have been dependent upon a chronic coli infection, or be regarded as within the limits of the normal. Dudgeon, Wordley, and Bawtree, from their observations with normal human sera, and the sera from proved coli cases, considered that a reaction of 1–50 with their antigens at 52° C. for five hours was abnormal. In these cases we have taken 1–100 as the lowest limit for the reaction, although the antigens employed and the technique adopted have been the same. If we regard the reactions in these cases as positive evidence of a colon infection, then we must look for evidence of a chronic infection. There was positive evidence of chronic inflammation with fibrosis of the appendix in six cases, but colon agglutinins were not present in the sera of these patients.

THE APPENDIX.

Contents.—The interior was fully examined in each instance. In one case in which the appendix was found to be normal, the interior was filled with inspissated fæcal material which consisted of phosphates and vegetable matter, while the acute symptoms were due to a hæmorrhagic lutein cyst in the right ovary.

In 27 cases, fæcal material was present in 2 (the normal cases referred to), creamy pus filled the interior in 3, in 18 cases the contents consisted of blood-stained pus, while in 4 instances it was blood-stained débris. In 6 out of the 25 acute cases concretions were present in addition to the pus or blood. Film preparations of the pus or blood-stained débris showed large numbers of bacteria, sometimes in solid plugs, while in one instance spirochætes were present in enormous numbers, in the lumen and mucosa of the appendix in a female patient, age 16, who had not been abroad. In 3 cases the terminal one-third or two-thirds showed an inflammatory reaction, while the base was unaffected to the naked eye.

The *concretions*, which were generally grey or greyish-white in colour, consisted of soaps and fats either with or without vegetable matter, but the soaps and fats formed the major portion of the concretion in each instance. No ova or entozoa were found in the interior of the appendix or in the concretions in any one of the 25 acute cases, although a very careful search was made, which included scraping of the mucosa. Bacteria were present in the concretions in large masses, but no foreign body was found.

The late Owen T. Williams drew attention to the white, soft, soap-like concretions in the appendix in appendicitis. His analysis showed that these concretions were similar to intestinal sand, and consisted largely of soluble fats and insoluble soaps, with a high calcium content of 3·3 per cent. He referred to Schmidt, who has stated that the intestinal mucosa excretes inorganic salts of iron, calcium and phosphoric acid, and fatty substances; and to the work of Sir William Macewen, who demonstrated a secretion in the appendix during life. Williams found that concretions in the appendix

contain insoluble calcium soaps of saturated fatty acids, which are formed by the secretion of the appendix, and are not fæcal concretions.

Williams suggested further that the fat compounds secreted or excreted by the tubular glands of the intestine may, under abnormal conditions, block the lumen of the glands, and so render them liable to be more easily infected by micro-organisms than would occur when functionating normally.

BACTERIOLOGICAL FINDINGS.

The Peritoneal Fluid.—Cultures were made of the peritoneal fluid around the inflamed appendix in 12 instances. It was sterile in 4, *S. albus* was present on 3 occasions, once alone and twice with either streptococci or colon bacilli, while in 5 instances the positive findings in the peritoneal fluid were similar to those obtained from the interior of the appendix, and showed non-hæmolytic *B. coli* and streptococci.

Anaerobic.—The pus, blood, and débris obtained from the tiles after drying was added to Robertson's heart medium, and sub-cultures were made from this at the end of twenty-four to seventy-two hours. In five cases *B. Welchii* was isolated from the interior of the appendix, as shown in *Table I.*

Table I.—Bacteriology of Interior of Appendix.

No.	No. of Case	Condition of Appendix	Aerobic	Anaerobic	Results
1	11	Normal ..	Enterococcus .. Slow lactose fermenter (N.H.)	*B. Welchii*	Recovery
2	18	Terminal end necrotic	Streptococcus .. *B. coli* (N.H.)	do.	do.
3	22	Suppurative appendicitis	*B. coli* (N.H.) ..	do.	do.
4	23	do.	Streptococcus (N.H.) Enterococcus (N.H.) *S. albus*	do.	do.
5	26	do.	*B. coli* (N.H.) ..	do.	do.

B. Welchii was not obtained from the peritoneal fluid. In one of these five cases the appendix was normal; but in the other four suppurative inflammation had occurred, and, although aerobic organisms were present, such as colon bacilli or streptococci, gangrene occurred in one case only. Each patient with this infection made an uninterrupted recovery. These findings are similar to those reported in the work of Dudgeon and Sargent on the bacteriology of peritonitis. In 1898, however, Veillon and Zuber drew attention to the importance of anaerobes in appendicitis. They considered that gangrene and the severe toxæmia were due to these organisms. Tavel and Lanz arrived at similar conclusions. In four acute cases and one normal appendix an

important anaerobe was isolated from the appendix out of 27 cases, but the clinical condition of these patients was not different from the rest, and the surgical treatment and the progress of the case were in no way affected.

Aerobic.—The dried pus, blood, and débris were scraped off the tiles in each case and spread on human blood-agar plates and also on plates of agar and litmus lactose agar. By this means it was a simple matter to select the isolated colonies on the various media. The aerobic organisms obtained from the pus and débris, or débris only, in the interior of the appendix in the 25 cases of acute appendicitis (thirty hours) are as follows: *B. coli*, 6; *B. coli* and streptococci, 14; streptococci and *S. albus*, 3; *B. coli*, streptococci, and *S. albus*, 2.

We will now discuss these results in detail.

Bacillus Coli.—In every case, without exception, the colon bacilli were of the non-hæmolytic variety, which is of considerable interest in the light of the work done by Dudgeon, Wordley, and Bawtree, who showed that hæmolytic colon bacilli occur in the fæces under normal conditions in about 13 per cent, but in cases of diarrhœa and colitis they were much more frequently obtained (35·4 per cent). Herrold isolated hæmolytic colon bacilli from the fæces in 40 per cent of his cases of renal infection due to these organisms, while the above-mentioned authors correlated the urinary and fæcal findings in hæmolytic coli infections. In these cases of acute appendicitis examined within thirty hours of onset, hæmolytic colon bacilli were not obtained in any instance, although every attempt was made with liquid and solid media. In 1922, one of us (L. S. D.) isolated a pure growth of hæmolytic colon bacilli from the blood and pus obtained from the interior of the appendix in acute appendicitis, but the appendix was full of thread-worms. This colon bacillus was grouped with a hæmolytic colon anti-serum (Dow).

It has already been stated that *B. coli* (N.H.) were isolated from the urine in three of these cases of acute appendicitis, and the organisms from both the urine and peritoneal fluid agreed serologically in one instance. *B. coli* of the non-hæmolytic type were isolated from the interior of the appendix in 22 out of the 25 acute cases. Several strains were taken from each case and tested culturally, but no information was obtained by this procedure, which agrees with the findings obtained with non-hæmolytic colon strains in urinary infections. Each strain was cultivated in veal broth and agar, and antigens were prepared which were tested with the colon anti-sera. In 11 instances, non-hæmolytic colon bacilli were isolated from individual cases which agglutinated with the non-hæmolytic colon anti-sera prepared from urinary strains, and none with the hæmolytic anti-sera.

Of course it is possible that if an unlimited number of colonies from every case were tested serologically, a higher percentage of positive findings might be obtained.

Streptococci.—Streptococci were isolated from the interior of the appendix in 19 cases out of the total of 27, in one case in the blood culture, and in another from the peritoneal fluid as well as from the interior of the appendix. A hæmolytic streptococcus was obtained in one instance only. This was a short-chained streptodiplococcus isolated in conjunction with a non-hæmolytic long-chained streptococcus, but the degree of hæmolysis was very slight.

The cultural reactions of the streptococci, long and short chains and diplococci, in lactose, inulin, mannite, salicin, and milk, and the results of the hæmolysis tests, are recorded here. No detailed description is appended, because distinctive records were not obtained by these methods.

Table II.—To Show the Cultural Reactions of the Streptococci Isolated in these Cases.

	Hæmolysis		Lactose	Inulin		Mannitol		Salicin		Milk	
	+	−	+	+	−	+	−	+	−	+	clot
Long chains .. 6	0	6	6	1	2	1	5	5	1	2	2
Short chains .. 5	0	5	5	2	2	2	2	5	—	1	4
Diplococci .. 13	1	12	13	5	5	9	3	10	1	5	7

+ = Acid. - = Alkaline or unaffected.

In some cases a long-chained streptococcus and a diplococcus or other combination among the members of this group were found. Hæmolytic streptococci, of the short-chained type, were isolated in only one case, although the hæmolytic tests were done with solid and liquid media. No fatal result ensued, and there was no instance of diffuse peritonitis with septicæmia, or cellulitis. The only case from which a streptococcus was isolated by blood culture made an uneventful recovery, but this streptococcus was the short-chained type, and non-hæmolytic. Similar streptococci were isolated from the urine in two cases, and from the interior of the appendix.

Mutch considers that delay of the intestinal movements is one of the chief factors which favour streptococcal growth in the colon, especially when associated with the presence of carbohydrates in the food, while others consider that diarrhœa favours an excessive streptococcal growth. Controversial arguments on this subject are largely due to ignorance of the fact that the streptococcal content of normal human fæces can be shown to be as high as is met with in conditions of ill health, provided the correct technique is employed. This question has been referred to by Dudgeon before the Section of Tropical Medicine of the Royal Society of Medicine.

There is a type of organism occurring characteristically in the fæces which has the classical fermentation properties of the central type of *Streptococcus fæcalis* group of Andrewes and Horder, and which withstands heat. Dible considers that this organism is the enterococcus. Heat-resistance is a characteristic property of the enterococcus, as most strains can withstand thirty minutes at 60° C., although fifteen minutes at 60° is the most satisfactory period. Most of our streptococcal cultures were heat-resistant.

MICROSCOPY.

Portions of the recently-removed appendix were examined by the ordinary methods and for fibrin, bacteria, fat, and in acid bichromate at 45° C. for fat. Giemsa's stain was also employed, and the tissues were examined by Levaditi's method for spirochætes.

Twenty-seven specimens which had been subjected to full bacteriological and other investigations were examined, as referred to above, and also ten quiescent appendices. Whenever possible portions from the proximal and distal ends, or from the most advanced lesion and the least affected portion, were compared.

Acute Cases.

The most extreme inflammatory changes were observed either as a localized or diffuse process in the wall of the appendix, while, as might be expected, all stages of inflammation were demonstrated. In 4 cases acute changes at one end of the appendix were compared with the normal appearances at the opposite end. In these acute lesions the mucosa was largely necrosed, or a false membrane consisting mainly of polymorphs and fibrin formed the lining wall in the inflamed area beyond the stricture. We failed to observe any marked excess of eosinophils in these acute cases. Eastwood considered that an eosinophilia occurs in the mucosa in appendicitis twenty-four hours after the onset of the attack, and reaches a maximum in the second week, but this localized eosinophilia is not associated with an eosinophilia in the blood.

In the most extreme cases, wide areas of necrosis occurred, with acute inflammation of the vessel walls, hæmorrhages, and thrombosis. The thrombi consisted chiefly of polymorphs or of blood débris. Similar changes occurred in the muscular coat: the muscle cells were swollen, vacuolated, and distorted, and showed fatty degeneration. There were scattered hæmorrhages present, and tracts of œdema free from cellular exudate.

Table III.—Showing Evidence of Chronic Inflammation in Acute Cases.

No. of Case	Clinical History	Evidences of Chronic Inflammation
2	No previous attack	Chronic inflammation with fibrosis
9	ditto	Chronic inflammation with fibrosis which extends all through the muscular coat up to the mucosa
14	ditto	Fibrosis of muscular coat especially.
22	One previous attack	Chronic inflammation all through the appendix
25	Several previous attacks	Marked fibrosis of muscular coat, vessels very fibrosed

The mucosa may show relatively few changes, or small areas of ulceration may be met with communicating with much more extensive inflammatory processes in the muscular coat up to and including the peritoneal covering and peri-appendicular fat. Foci of necrosis occurred in this fatty tissue. The inflammatory reaction may be intense in the submucous and muscular coats, but very slight in the mucosa. Degeneration of the ganglion cells occurred. Spirochætes were abundant in the mucosa and in the lumen of

the appendix in one case, but, as already stated, this patient had not been abroad. It is important to realize that in 5 out of the total of 25 cases of acute appendicitis, positive evidence of chronic inflammation and fibrosis was obtained in addition to the acute changes, as referred to in *Table III.*

One case of oxyuris infection occurred among these acute cases. Reinhardt found about 10 per cent of 620 appendices removed up to 1919 contained oxyuris, and during 1919 17·6 per cent out of 170. He considers that localities and seasons may raise the oxyuris index.

FIG. 356.—Zeiss A objective. B_6 ocular. *Case* 2 (*Quiescent*) showing 'fats' at the base of the columnar epithelial cells of the mucosa and glands, with clumping of fats in the central area of the lymph nodes in the appendix wall.

Eastwood found that 19·2 per cent out of 73 cases of appendicitis, and 28 per cent out of 50 normal appendices, had an oxyuris infection.

Fats.*—Fat droplets, large masses of fat, and needle-shaped crystals of soaps were present in the interior of the appendix. Fats were present in the cells of the inflammatory exudates, and muscle fibres which were not disorganized contained large and small fat droplets. The lymph follicles in

* This term is used to include all substances reacting with Scharlach R.

the wall of the appendices showed small and large coarse fat droplets, especially in the endothelial cells, and these droplets may be of such large size, or so numerous, as to obstruct the outline of the cells. The fats were especially abundant in the endothelial centres. A lymph gland from the mesentery showed the fats in abundance in the centre of the lymph nodes, as occurs in these nodes in the appendix wall. Fats were abundant in the mucous coat, and in the deep epithelium of the tubules, and especially in and around the ganglion cells.

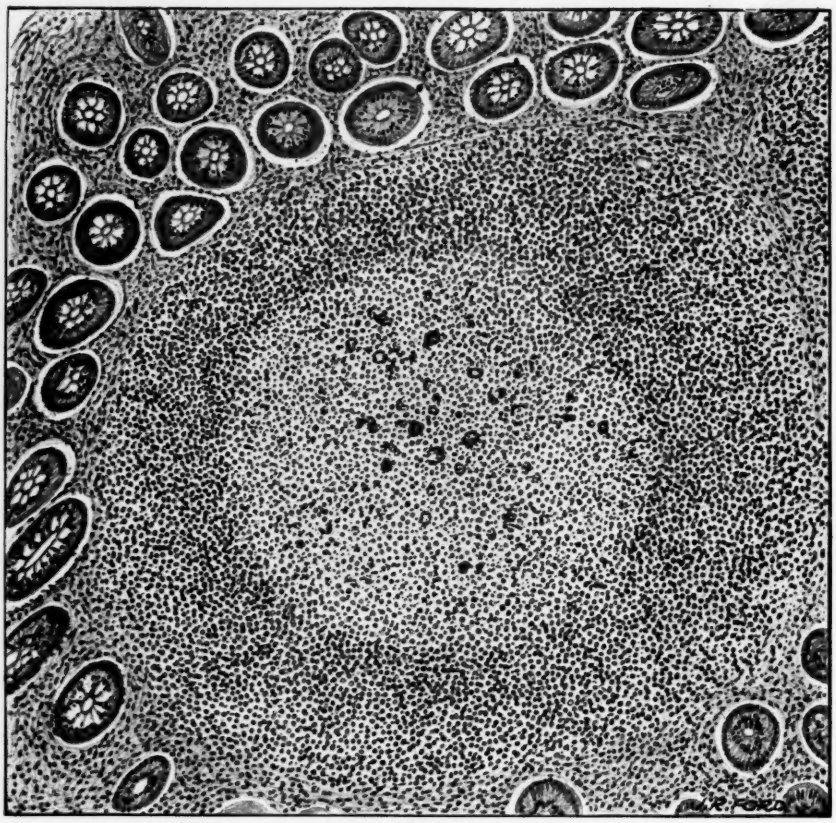

FIG. 357.—Zeiss A objective. B_6 ocular. *Case* 8 (*Quiescent*). Showing 'fats' in the epithelium and in the lymph nodes as in *Fig.* 356.

QUIESCENT CASES.

Ten quiescent appendices were removed, and examined especially for the presence of fats. The contents were examined and sections prepared as in the acute cases. No bacteriological examination was made. It may be as well at the outset to refer to the gross changes found in the appendix in these ten cases of quiescent appendicitis. In eight out of the ten cases no abnormality was observed in the mucosa; in one case the mucosa was apparently replaced by fibrous tissue, and in the last case the lumen was packed and the mucosa covered with thread-worms. One case of acute appendicitis occurred

in the present series in which thread-worms were demonstrated, but from long experience we have no belief that these worms are a frequent cause of appendicitis in this country. In every case the lumen was fully patent, apart from the thread-worm case, but there was obvious fibrosis of the outer coats.

The microscopical examination confirmed the gross findings, as the mucosa was normal in 8 out of the 10 cases. In one case the mucosa was largely replaced by fibro-fatty tissue, and in the other case masses of ova of the oxyuris were present. No local eosinophilia occurred in this case,

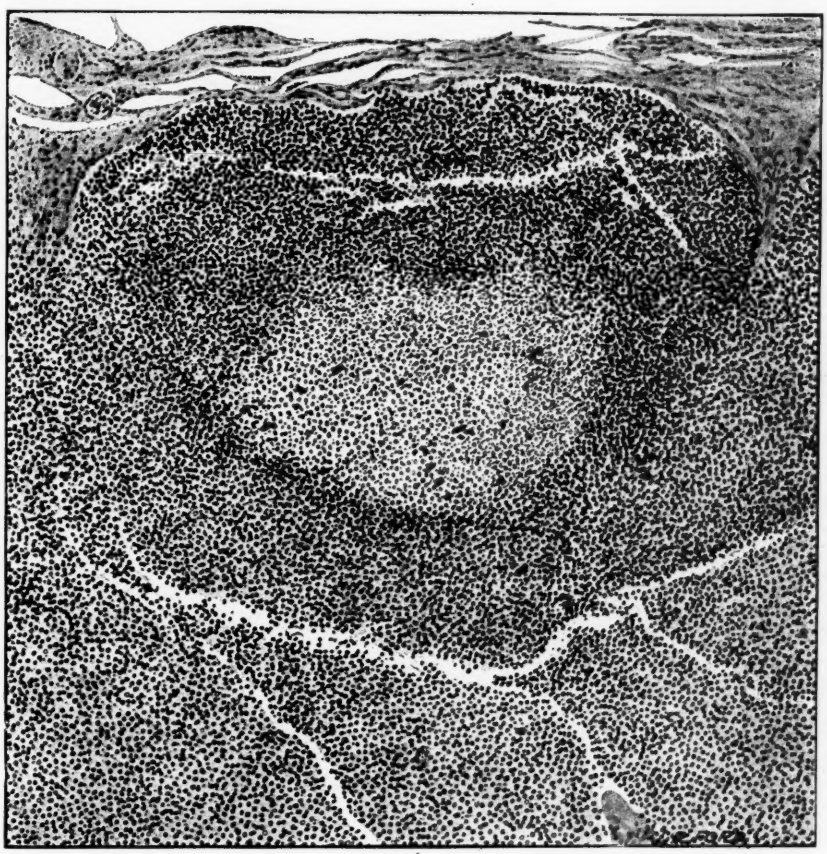

FIG. 358.—Zeiss A objective. B_6 ocular. *Case* 8 (*Quiescent*). Lymph node from the meso-appendix of the same case, showing the same clumping of fats in the central area. A similar condition was to be noted in a lymph node removed from the ileocæcal angle and presumably draining the appendix. All these lymph nodes were much enlarged in this case.

which confirms Eastwood's findings. In 9 cases out of the 10 examined the amount of lymphoid tissue was within the limits of the normal.

In one instance endothelial activity in the centre of the lymph nodules was considerable, with phagocytosis of the lymphoid cells. The fibrosis was chiefly at the expense of the muscular coat, so that in some cases such muscle as remained was embedded in dense fibrous tissue.

In addition, the vessel walls were thickened and the lymphatics in the

outer coat dilated. In the fibrous tissue which extended from the submucous to the peritoneal coat, areas of chronic inflammation occurred, and in one instance a deposit of brown pigment, which was not iron-free.

The interior showed plugs of bacteria mixed with the fæcal material, and in one instance, a female, age 12, who had not been abroad, spirochætes were abundant.

The Fats.—It is, however, especially in relation to the presence of the fats that we are now concerned, but some idea of the condition of these

FIG. 359.—Zeiss A objective. B_6 ocular. *Case* 10 (*Quiescent*). Showing a mass of ' fats ' in the lumen of the appendix and in the epithelial cells of the mucous membrane and glands. Clumping of ' fats ' in the centre of the lymph nodes is again present.

quiescent appendices was essential before the fat details were referred to. Considerable advantage has been gained by employing the bichromate method of Bell for these fresh tissues. (*Figs.* 356–359.)

The fats were found in abundance in the lumen of the appendix with the fæcal material, in the cells of the lining epithelium of the mucosa, especially in the deeper portion of the epithelial lining, and in some instances the fats were present here in very considerable amount.

It is, however, the presence of the fats in the lymphoid tissues of the appendix which is such a striking picture, and especially in the endothelial centres. The fats are present in single droplets, in large clumps, free, and packed in the endothelial cells. We were fortunate to obtain the small lymph gland attached to the appendix in three instances, and here the fats were also found to be abundant, more especially in the endothelial centres, in clumps, and in individual droplets, free, and phagocytosed by the endothelial cells. These fats were present in the tissue as round droplets, but the angular or solid forms were also met with.

The fats were present in abundance in the ganglion cells, as in the acute cases, and in close proximity to these cells. The muscle fibres in the appendix wall showed fat droplets, but not to the same degree as in the swollen muscle-cells in the appendix wall in acute appendicitis.

The presence of these fats in the free mucous lining of the interior of the appendix, in the deep epithelial cells, and especially in the endothelial centres of the lymphoid nodules and of the lymph glands draining these areas, suggests to us the probability that fats are absorbed from the lumen of the appendix.

As already stated, Owen Williams brought forward strong arguments in favour of the opposite view: that these fats were excreted by the mucosa of the appendix, and that appendicular concretions were formed in this way. The fact that we have been able to demonstrate fats both free, and phagocytosed, in the lymphoid nodules of the appendix and the corresponding lymph glands, is in support of the view which we offer.

Unless otherwise stated, the appendix showed no signs of previous inflammation, nor adhesions to adjacent structures. The sex incidence in this series is approximately equal, which tallies with a long experience of several years at St. Thomas's Hospital. In all cases recovery was uneventful.

CHRONIC APPENDICITIS.

Of the 10 consecutive cases operated on in this series, 5 were male and 5 female, of ages ranging from 2 years to 30 years. In no case was the operation performed less than two months after the last acute attack, and in all cases there was no outward sign of previous inflammatory change either in the appendix or peritoneal cavity. In one case, that of a female, age 19 years, masses of thread-worms could be felt in the cæcum, and were also found in the appendix. This patient had spent much of her life in Southern India. In another case, a female, age 2 years, where laparotomy was undertaken for an intussusception which was of the cæcocolic type, the appendix was very long and apparently the cause of the trouble.

CONCLUSIONS.

1. The chief aerobic organisms isolated from the interior of the appendix in the first thirty hours of appendicitis were *B. coli* and streptococci. These organisms with one exception (streptococcus) were non-hæmolytic. Twenty-five acute cases were investigated. The anaerobe, *B. Welchii*, was present in four of these acute cases, but the organism failed to reveal its pathogenicity, and from one normal appendix.

Table IV.—Clinical Notes on the Acute Cases of Appendicitis Investigated in these Experiments.

No.	Sex	Age	Length of Attack in Hours	Previous Acute Attacks	Operation Findings re Appendix
1	F.	21	12	1	Curled up in retrocæcal pouch and generally inflamed
2	F.	19	12	0	Distal end distended and much inflamed. No kinking of organ
3	F.	25	12	0	Distal end inflamed
4	M.	15	15	0	Distal end inflamed and wrapped in omentum —appendix pelvic in position
5	M.	14	24	0	Generally inflamed—pelvic in position
6	F.	23	15	8*	Fibrotic and generally inflamed—no adhesions
7	F.	9	24	0	Generally and very intensely inflamed
8	M.	24	30	0	Generally inflamed—enormous quantities of free serous fluid in peritoneum
9	M.	20	20	0	Distal half distended and inflamed, wrapped in omentum
10	M.	11	8	0	Kinked by old adhesions and inflamed distally
11	F.	16	24	0	†Pelvis generally inflamed. Large blood cyst of ovary (R.), apparently seat of recent hæmorrhage
12	F.	8	7	0	Generally inflamed—retrocæcal
13	M.	56	2	0	Generally inflamed—retrocæcal
14	F.	15	9	0	Generally œdematous, wall thickened
15	F.	45	24	0	Generally inflamed—free fluid purulent
16	M.	16	24	1‡	Generally inflamed—free pus
17	F.	26	24–30	? 1	Generally inflamed
18	F.	8	10	0	†Appeared normal—enlarged glands in mesentery
19	M.	33	19	Several	Generally inflamed, adherent and fibrotic
20	M.	33	20	?	Tip red. No kink. Much serous fluid
21	F.	21	20	?	End inflamed beyond kink. Much serous fluid
22	F.	14	6	1	Much inflamed. Free serous fluid
23	F.	12	24	1	Kinked and much inflamed distally
24	M.	29	24	? 1	Generally inflamed and pelvic. Very adherent
25	M.	24	24	Several	Generally inflamed, pelvic. Free sero-pus
26	M.	16	20	? 1	Inflamed distal to kink
27	M.	25	24	0	Generally inflamed

* These occurred regularly after menstruation, last one month previously.
† Appendix normal microscopically. ‡ Three months ago.

2. *B. coli* was not obtained by blood culture, and streptococci were found in only one case.

3. All cases recovered without complications.

4. *B. coli* infection of the urinary tract was present in three cases.

5. Serological tests were made with the anti-colon sera and with the isolated strains of *B. coli*, with positive results in half the cases.

6. Intestinal parasites were found in one of the acute cases, and in only one of the ten control cases of quiescent appendicitis (oxyuris).

7. Appendix concretions consisted of fats, soaps, and vegetable matter.

8. Fats were demonstrated in the lumen, mucous lining, in the gland cells, in the lymph nodes of the appendix wall, and in the lymph glands draining the appendix in the quiescent cases. These findings suggest fat absorption from the lumen.

9. In many of the acute cases the inflammatory process in the submucous and muscular coats was much more intense than the appearance of the mucosa led one to suspect.

10. Evidence of chronic appendicitis was demonstrated in the wall of the appendix in some of the acute cases, although no previous history of appendicitis was obtained.

11. In the chronic cases, and in the acute cases where evidence of previous inflammation existed in the appendix wall, the fibrosis involved the muscular coat, which was extensively disorganized.

12. Spirochætes were found in two cases, and these patients had not been abroad.

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THE PROBLEM OF DRAINAGE IN ACUTE APPENDICITIS.

By R. ST. LEGER BROCKMAN, Sheffield.

(Being the Hunterian Lecture delivered at the Royal College of Surgeons of England on Jan. 21, 1924.)

" Why then is not the wound of the daughter of my people closed ? "
—*Jeremias* ix, 22 (Douai version).

The history of progress in the treatment of most diseases reveals a series of stages or periods each of which presented its own peculiar problem to exercise the surgical minds of the time. In the practice of the art of healing, we have to tread a path which is strikingly similar to that taken by what to many of us was the most appealing figure of our fairy tales, the suitor who essayed to win the hand of the king's daughter. No sooner is one riddle answered, or one task completed, than another is immediately propounded in its place. We ever repeat the experience of the climber who, thinking the next ridge is the summit to be attained, finds that another rise still stands between him and his allotted goal.

In the not so far distant past the clinical picture of this disease was that of an acute phlegmon of the abdominal wall. The treatment was clear, and afforded no loophole for argument. The problem lay between appendicitis and typhlitis as the underlying cause. This question solved, there arose the stage of discussion over the respective merits of physician and surgeon in dealing with such cases, and more so over the most propitious moment for active interference. The ever-increasing rule of operating on patients as soon as the diagnosis was made at once increased the number and variety of pathological lesions which came beneath the notice of surgeons. What one may call the age of the localized abscess with its inevitable treatment gradually began to pass.

Thus there appeared the problem of drainage in acute appendicitis which is still with us, and to which I propose to attempt an answer.

A good surgeon has been defined as " one who always knows when to put in and when to take out a drainage tube ". If this be so, then there are few other conditions in general surgery which will so often test the standard of our skill. The dictum of Lawson Tait, " When in doubt, drain ", is still the final word in many discussions on this subject. Admirable as such advice has been and is, we must remember that doubt spells ignorance, and complacently to submit one's actions to the ruling of such a motto is to spend a life of surgical stagnation.

HISTORICAL.

The earliest suggestion that removal of a gangrenous appendix in the presence of purulent peritonitis can conscientiously be followed by closure was, I think, made by Mikulicz,[1] of Krakow, in 1884. Unfortunately he

failed to find the appendix, and the patient succumbed to the peritonitis in five days' time. The autopsy revealed a perforated appendix. The following sentence of his report is significant: "Had I sought farther for the origin of the exudate, had I investigated the neighbourhood of the cæcum by sight as well as by touch, the perforation of the appendix could not have escaped me, and I should have excised it entirely and closed the opening into the cæcum by sutures. And I am convinced the peritonitis would then have subsided, and the patient would have been saved". Some months later he treated a perforation of the small intestine on these lines, with perfect success.

Others were not so fortunate, and surgery entered upon an era, lasting in many quarters until the present time, which was, and is, dominated by an obsession that a peritoneal exudate of purulent appearance is of necessity pus demanding drainage. To this point I will return later.

In the early part of this century the custom was to provide free and abundant drainage in cases of appendicular peritonitis. Broca[2] in 1906 lectured in London in such strain. In the year 1902 Lockwood[3] expressed the opinion, "Probably all will agree that when pus is encountered the wound should be drained", and from the context it is clear that he spoke of intra-peritoneal drainage.

At a surgical conference held in Paris in 1911 the general trend of opinion, expressed at a discussion on this subject, was that all cases of acute appendicitis should be drained save very early and exceptional ones. There was, however, evidence that surgeons in various parts were gradually attempting to cut down the amount of drainage employed. Bauer, of Stockholm, told the congress that he had come little by little to do away with drainage in free appendicular peritonitis. The work of Yates,[4] showing the futility of hoping to drain the peritoneal cavity, was beginning to bear fruit.

In 1912 Grant Andrew,[5] of Glasgow, reported a series of cases to support his contention that general closure of the abdomen after appendicectomy in acute cases should be the rule and practice of surgeons. The atmosphere of his reception was, one gathers from the tone of the discussion which ensued, hardly what a Spaniard would call 'sympatico'. The main criticism levelled was that he was attempting a routine treatment of a condition in which each instance must be considered on its merits.

During the years of the war such a subject naturally almost disappeared from the leaves of the Index Medicus.

The year 1920 saw the question again debated amongst the surgeons of Paris. The discussion took place as the result of a paper by M. Ombredanne[6] in which he pressed for closure without drainage of all acute cases irrespective of the condition of the anatomical lesions which was found at operation. His sole condition was that the appendix should have been removed. His views roused much hostile criticism, but it is most interesting to note the large strides which general opinion had made in ten years.

The words of Hartmann[7] well bear repetition: "L'indication du drainage résulte non de la présence du pus dans la cavité abdominal, mais de l'existence des particules non résorbables, portions mortifiées de sérouse au contact d'un appendice gangrené, fausses membranes abondantes, présence

d'une surface cruentée et saignantée". This expression of opinion, first given in 1912 and reiterated in 1920, may be taken as a fair summary of the general feeling of the meeting held in the last-named year.

The trend of papers which have appeared in the surgical literature of all lands during the last few years is all towards the elimination of drainage as far as is safely possible in this condition.

THE SCOPE OF THE PRESENT OBSERVATIONS.

The present paper is the outcome of investigations into the methods of treatment and the results of cases of acute appendicitis which have passed through the surgical wards of the Royal Infirmary, Sheffield, during the three years 1921–23. Only instances of undoubtedly acute inflammation have been included in this series of over 1000 cases. I have made special notes of the causes of death in so far as this event had any bearing on the question of drainage, but otherwise I have purposely rather neglected the pathology of the post-mortem chamber and the realms of experimental work. I have striven to find an answer to my problem according to the dictates of Moynihan's pathology of the living. I shall therefore attempt to show from the result of these observations that the moments of our doubt can be dispelled by a careful interpretation of the clinical and operative findings in each individual case. I fully realize that some will accuse me of rashness, others of being over-cautious, but I maintain that all treatment, if it be rational, must strictly follow the fundamental laws of surgical pathology. Therefore, adhering rigidly to this principle, I have formulated an answer to the question of drainage, which I believe to be in full accord with the best welfare of the patient and with the peace of mind and reputation of the surgeon.

THE ADVANTAGES AND DISADVANTAGES OF DRAINAGE.

The first question which naturally arises in our minds is as to whether anything is to be gained by the elimination of general drainage which has been in vogue so long, and, if so, to what degree the patient will benefit. What, in other words, are the relative advantages and disadvantages of drainage in such cases? There are many instances where local conditions of hæmorrhage and necrosis will insist on an outlet being provided. There are, however, a large series of cases where it is solely the presence of a purulent exudate which has from long-continued custom necessitated the use of a drainage tube.

In such cases in the main the sole advantage of the practice is what has been spoken of as the hypnotic influence of the presence of a tube on the surgeon himself. There is an old tradition dating from the early days of cœliotomy which leads us to think that a fatal result in an undrained case might have been avoided had drainage been used. This, I think, is untrue, unless closure has taken place in the presence of an actual abscess or of a potential one. If the death is the result of lack of drainage, then there is no doubt about it, since the subsequent happenings point only too clearly to this being the case. In his article on the treatment of peritonitis cases, Blake[8]

concludes with the following sentence: "Some need drainage, some do not; some seem to do better with irrigation, others get well without irrigation or drainage; and some die whether drained or not, washed or unwashed". The kernel of truth contained in these words is that, in the absence of what we call a power of general resistance on the part of the patient, we are helpless. No amount of drainage will give the patient what he lacks in this respect. The use of drainage or otherwise should be determined by the local condition aided by certain general observations in each case. The death from failure to cope with his infection is rapid and distinctive in character. It differs greatly from that due to want of drainage, and the two can easily be distinguished.

Further, it is in a very small percentage of cases that anything escapes from the tube. In some it undoubtedly does, often in copious amounts, and it is these cases which demand drainage and which, I hold, give a definite indication of its necessity.

Thus I believe that the hypnotic effect of the drainage tube stands alone as the main advantage of the general use of such procedure in diffuse appendicular peritonitis.

What now are the advantages of dispensing with the use of drainage? The occurrence of fæcal fistulas with the enforced delayed convalescence is infinitely more frequent in cases in which a tube has been used. Secondary hæmorrhage has not occurred in any case of this series, drained or undrained; but in no patient has the tube remained *in situ* longer than seventy-two hours. The residual abscess has not arisen in any undrained case, though the same cannot be said of the other class. Of the cases under review, six have come back to hospital after healing, with an attack of acute intestinal obstruction due to bands. In all instances they were cases which had been drained at the primary operation. How can this feature be explained? The origin and formation of peritoneal adhesions is a question of great difficulty and complexity. One point, however, can, I think, be maintained with a comparative degree of certainty. The type of adhesion which gives rise to trouble of this kind is the outcome of a chronic rather than of an acute infection. The drainage tube is soon closed off by adhesions from the general cavity. Now Yates[4] observed in his experimental work, and it can be noted in a careful post-mortem examination, that the neighbourhood of the tube tract is the common situation of residual abscesses. So a small residual abscess is formed in which the organisms die off, and a chronic collection of pus results. This becomes inspissated and later organized. The movements of the intestine stretch this newly-formed fibrous tissue until it becomes a band which is the cause of the obstruction.

The clinical picture of the convalescence is infinitely more pleasant for the patient in cases in which drainage has been avoided. And lastly, the length of time which such convalescence lasts is considerably curtailed by the practice of non-drainage, as can be seen from the tables.

This is, I think, sufficient evidence that it is well worth our while to eliminate the use of a foreign body in the form of a drainage tube as far as possible in our practice of surgery in such cases.

THE RESISTANCE OF THE PERITONEUM.

"Tell me, I beseech thee, wherein thy greatest strength lieth."
—*Judges* xvi, 6 (Douai version).

Advance in a systematic and logical manner in the inquiry on this subject calls at the outset for a satisfactory explanation of the reason for the pre-eminent powers of resistance possessed by the peritoneum, the existence of which is an acknowledged fact. The ideas of many on this point are too often nebulous and ill-considered. The use in teaching of such phrases as "the selective action of the peritoneum" and "the peritoneum can look after itself" merely tends to conjure up before the mind of the listener a vision of a membrane in the endothelium of which lies some mysterious faculty in which the rest of the body organism is lacking. He is apt to regard the peritoneum as the possessor of the ten talents of secret protective power. With the obvious fact of the existence of such powers he is perforce satisfied; their abode he is prone to regard as lying beyond his ken, hidden away in some at present unsuspected corner as was the secret strength of Samson until it was laid bare by the wiles of the crafty investigator. Some tissues fall an easy prey to certain organisms which fail to affect other parts, but the peritoneum can deal in a very special manner with all and sundry. There is, as far as I can see, no reason in the world why we should look for some obscure and wonderful special immunity in the peritoneal endothelium, since it is born, bred, and has its being in the same surroundings as the other tissues of our structure. Furthermore, the simpler an acceptable explanation of vital processes is shown to be, the more likely is the truth to abide therein. Delilah solved the secret of her quest by applying her knowledge of men in general to the particular case of Samson. We can, I think, be equally successful if we will but apply our general experience of the facts and features of inflammation to the individual instance of the peritoneum.

Compare for a moment the effects of infection with the staphylococcus group of organisms in different parts of the body. It is the most universally present organism in cases of peritonitis. In the skin and subcutaneous tissues it usually causes the acute abscess of limited dimensions; the eye-ball it rapidly disintegrates; in joints, if not rapidly relieved, the articular structures fall before the onslaught; in bone, however early we locate it, widespread necrosis and sequestrum formation invariably follow. These several sequences are marvellously constant, allowing for even wide differences in the virulence of the infection and the resistance of the individual. How then are they to be explained? The great tissue destroyer is a physical one, namely tension; and it is the absence of a rapidly acute tension with its concomitant destruction which explains the extraordinary resistive powers of the peritoneum to infection. How then is the freedom from such pressure provided for in the case of this membrane?

We can regard the peritoneal cavity as a vast tissue space which can accommodate copious pouring out of tissue fluids and exudate without such effusions causing pressure destruction of the cells lining that space. The ease with which fluid can pass through this membrane into the cavity is clearly seen if the peritoneum of a cat is inspected during the intravenous infusion of saline.

Further, in addition to the vessels of the peritoneum which normally carry blood—the service vessels—there is, according to Hertzler,[9] a further set which only dilate and carry blood under the stress of inflammation. Such vessels are described by Klein and Smith ;[10] but, according to their account, they often end blindly, and therefore these observers regarded them as freshly developing channels formed by the reactive processes. Hertzler maintains that by improved technique these end-vessels can be shown even in quiescent peritoneum to terminate in veins. Such a mechanism provides an immediate outlet for relieving pressure on cells as the result of acute inflammatory engorgement. These several methods also allow of a very rapid dilution of the toxins formed by the infecting agents.

The looseness of attachment of the peritoneum in the pelvis explains the greater resistance in this region as compared with that in the upper abdomen, where the membrane is firmly bound down to the substance of the liver and the diaphragm.

FIG. 360.—Peritoneum from a case of gangrenous appendix and purulent peritonitis. The intact but proliferated endothelium can be seen along the entire surface of the membrane.

Now how exactly does this lack of tension aid the resistive powers ? The limitation of an acute abscess is brought about by the excess of the constructive over the destructive elements of acute inflammation. This is manifested for us by the endothelial proliferation of blood-vessels, lymphatics, and tissue-cells in the zone of the so-called encapsuling area of the infection. A section of the peritoneum (*Fig.* 360) from a case of acute gangrenous appendix with a diffuse frankly purulent fluid in the pelvis shows that this defensive reaction can, through the lack of tension, be produced in the very forefront of the fray.

Such, then, is the reason for the existence of such powers of resistance which the peritoneum displays towards infecting agents. Therefore, I maintain, the problem of drainage depends for an answer first and last on the state of the peritoneum. The question we have to decide in every case is : Has the damage done by the original focus of infection gone so far that *restitutio ad integrum* is not possible after removal of the primary cause of the inflammation ?

If we are to close without drainage, we must leave behind an intact

peritoneum—intact, that is, when we close the abdomen, and, furthermore, one which will remain intact after closure. It is this latter condition, the problem of the potential abscess, which has mainly to occupy our minds. In the forefront of our vision must be the words of Murphy,[11] of Chicago, "The peritoneum abhors and will not tolerate abrasions".

TYPES OF CASES.

In the main we can divide our cases into three classes. I now propose to consider these in the order of their relative simplicity.

The total number of cases was 1068. Deaths, 51. Mortality, 4·7 per cent.

Table A.—Acute Appendix. Localized Abscess.

No. of Cases	Deaths	Mortality Per Cent	Complications	Average Stay in Hospital
36	3	8·3	Fæcal fistula 4 Obstruction 2 Re-opened 3	28 days

Causes of death: Acute obstruction 1
General septicæmia 2

The appendix was left in 7 cases.

Class A comprises those in which the condition was that of a frankly localized abscess with granulating walls which bled freely as soon as the pus was evacuated. These need detain us but for a short time. They call for drainage in all cases whether the appendix is removed or not. Those who would have us deal otherwise with these patients have simply lost all sense of proportion in their zeal for eliminating drainage. To claim, as has been done, that if the abscess re-forms it is simple to re-open and drain it, is to ignore the dangers of thrombosis and portal pyæmia intervening, apart from the often fatal ending of a second operation on such patients. In addition, advance receives a decided set-back, because in this instance such persons have defied one of the most ancient of the basic rules of surgery, and, in consequence, anything which they have to say with regard to other types of cases passes almost unheeded.

Table B.—Acute Appendix. Non-gangrenous or Perforated, with Free Fluid to Turbid Stage.

No. of Cases	Deaths	Mortality Per Cent	Complications	Average Stay in Hospital
390	1	0·25	Suppurated badly 42	13 days

Cause of death: Lobar pneumonia, 1.

Class B comprises the ordinary acute appendix which has become neither gangrenous nor perforated. Free fluid may be absent, or such as is present

is just becoming turbid. In a sequence of 390 such cases treated by appendicectomy and primary closure, no untoward result has accrued from such practice. The only instance of mortality was due to the onset of pneumonia three days after operation. Such cases, I believe, never require drainage in either adults or infants, save in those in which the acute attack occurs in a case where the appendix is buried in a mass of old adhesions consequent upon previous infections. Such removal may entail the leaving of a large area bereft of peritoneum from which the oozing cannot be stopped. In such a case an outlet is obviously required. No case in this class required re-opening for either obstruction or residual abscess. A certain number of wounds broke down, many others oozed varying amounts of turbid serum or pus, but in no case did this give rise to any anxiety as to the ultimate recovery of the patient. It is, I believe, quite unnecessary to suggest that this type of case requires any evidence gained from microscopic examination of the cellular or bacterial content of the peritoneal exudate to enable us to decide whether to employ drainage or not. They can all be closed with safety.

Table C.—Acute Gangrenous Appendicitis. Diffuse Purulent Peritonitis.

ADULTS.

DRAINED

No. of Cases	Deaths	Mortality Per Cent	Complications	Average Stay
352	30	8·5	Fæcal fistula 20 Obstruction 7 Re-opened for abscess 11	25 days

Causes of death: Within 36 hours .. 15; Paralytic ileus .. 5; Obstruction .. 4; Subphrenic abscess 1; Septic exhaustion .. 5

UNDRAINED

No. of Cases	Deaths	Mortality Per Cent	Complications	Average Stay
192	14	7·2	Cellulitis 29 Suppurated 160 Perforated 1 Re-opened 1 Fistulas 5	18 days

Causes of death: Within 36 hours .. 8; Cellulitis .. .. 1; Perforation .. 1; Paralytic ileus .. 3

INFANTS UNDER 12.

DRAINED

No. of Cases	Deaths	Mortality Per Cent	Complications	Average Stay
54	5	9·2	Fistula 8 Cellulitis 1 Re-opened 4	26 days

Causes of death: Within 36 hours .. 2; Obstruction .. 1; Septic exhaustion .. 2

UNDRAINED

No. of Cases	Deaths	Mortality Per Cent	Complications	Average Stay
44	8	18	Fistulas 1 Subphrenic abscess 1 Cellulitis 5 Re-opened or burst open 29	32 days

Causes of death: Within 36 hours .. 1; Cellulitis .. .. 2; Acute peritonitis .. 5

Class C embraces cases of gangrenous or perforative appendicitis with a diffuse peritonitis, often purulent in character. As can be seen from the

figures given, the vast majority of these can be closed without drainage of the peritoneal cavity. Others cannot, and we have now to consider the feature which will enable us to distinguish the latter class of case. In all such cases the peritoneum looks intact to the naked eye. The microscope does not reveal any changes to distinguish them. The section (*Fig.* 361) is an example of the peritoneal surface in all such cases. How is it, then, that we cannot close some, though the majority recover and benefit by primary closure? The cells have obviously undergone some destructive change, not apparent to eye or microscope, which ensures that if we close without drainage the potential becomes an actual abscess.

FIG. 361.—Peritoneum seen in cases of gangrenous appendix with purulent peritonitis. Neither to naked eye nor to microscope is it apparent whether the case requires drainage or not.

There are, I believe, certain very definite signs which will enable us to say which of such cases require drainage. In the absence of such evidence, I believe it is perfectly safe to dispense with drainage as far as the peritoneal cavity is concerned. This statement holds for all cases of this class. It matters not how gangrenous the appendix, how copious or foul-smelling the purulent exudate found free in the peritoneal cavity may be. If the indications for drainage which I shall enumerate are absent, then all such cases can be treated by primary suture of the peritoneum, and, moreover, they should so be dealt with.

I will now consider the evidence upon which our decision can be made.

INDICATIONS AS TO DRAINAGE.

Duration of the Disease.—The resistance of the peritoneum, depending, I believe, on the absence of tension, is only in the nature of a time allowance which this tissue receives. If we cannot remove the primary focus before this allowance is used up, the defences fail and tissue death results. Cases of this class which have been ill for longer than three days are more likely to need drainage than those dealt with earlier. Though it is important to ascertain the date of onset and allow it to weigh with us, yet we shall find in such cases other evidences which will aid us in our decision.

Age of Patient.—If I am asked which is the most valuable single point

of evidence, I should say the age of the patient. I am quite prepared to lay it down as dogmatically as possible from this series of cases that children of twelve years and under with a gangrenous appendix and purulent fluid in the pelvis will not stand closure as will adults in a similar condition. I have thought long over the reasons for this undoubted clinical experience. In the first place, I am of opinion that in an adult, if the attack which demands urgent operation is without doubt his first, the surgeon is going to have a more anxious case on his hands than if it is the culmination of a series of less acute attacks. Now in children of such tender years the attack for which we operate is almost invariably the first. The youngster has not had the opportunity in a few brief years to develop either a general or a local immunity to such infection. In addition, the whole march of events is more rapid, often even fulminating. The time allowance of which I have spoken is used up more rapidly, as is evidenced by the comparative frequency with which one meets that bleb-like œdema of the parietal peritoneum in children.

If such a child is closed without drainage, the subsequent history is similar in nearly all cases. They do not tend to develop a small localized abscess either in the pelvis or elsewhere. The damage to the peritoneum has been widespread, though at the time of operation it looked glossy and intact; neither have I been able to detect any degenerative change under the microscope which is not present in adults (*Fig.* 361). These children ooze pus from the whole surface of the peritoneum of the lower abdomen. If they are re-opened, as they should be, or if they are lucky enough to burst open of themselves, a large quantity of pus wells up from all directions and continues to do so for some days. If this does not happen, they usually die of a general peritonitis in four or five days. It is interesting here to study the temperature charts (*Fig.* 362) of adults and infants of a series of cases as similar in duration, and in clinical and local condition, as it was possible to collect.

Whilst there is little to choose either way between those of the drained and the undrained in adults, when we turn to children under twelve years of age we see a very different picture. The struggle for existence is much more marked and more prolonged in the case of the undrained infant. I am certain that in children of the first decade a purulent fluid within the abdomen demands drainage. They are almost invariably cases of what I have spoken of as the potential abscess. I fully realize the futility of arguing always from statistics; but the difference in the mortality-rate of the two methods of treatment in the case of infants as compared with that of adults is more than significant (*Table C*). The method of drainage I will come to later when I consider that point in detail.

Degree of Toxæmia.—This also I feel is one of the most valuable pieces of evidence we possess. It can be judged to a very large extent from the general appearance and facial expression of the patient. The peritoneum in the matter of absorption behaves as does the skin or other surfaces. The existence of stomata as so often described is a myth. Such structures do not exist. They have been shown beyond all doubt to be the products of microscopic preparations—pure artefacts. The power of absorption of toxic substances through an epithelial surface is increased by damage to the cells

of that surface. Little or no absorption of such bodies takes place through an uninjured peritoneum. The degree of toxæmia, then, is a very real guide to the extent of the damage which the infecting agent and its toxins have wrought on the peritoneal endothelium. This damage, as evidenced by an advanced state of toxæmia, is not visible to the naked eye, but is there nevertheless, since such cases, if closed, give rise to the most serious trouble. It is this factor which partly explains the danger of closing the infant to which I have just referred. Marked toxæmia with a rapid onset of the facies Hippocratica is especially a feature of children. As with the young, so with the adult who exhibits this clinical feature, the potential abscess is present in a very real degree, and drainage should be employed.

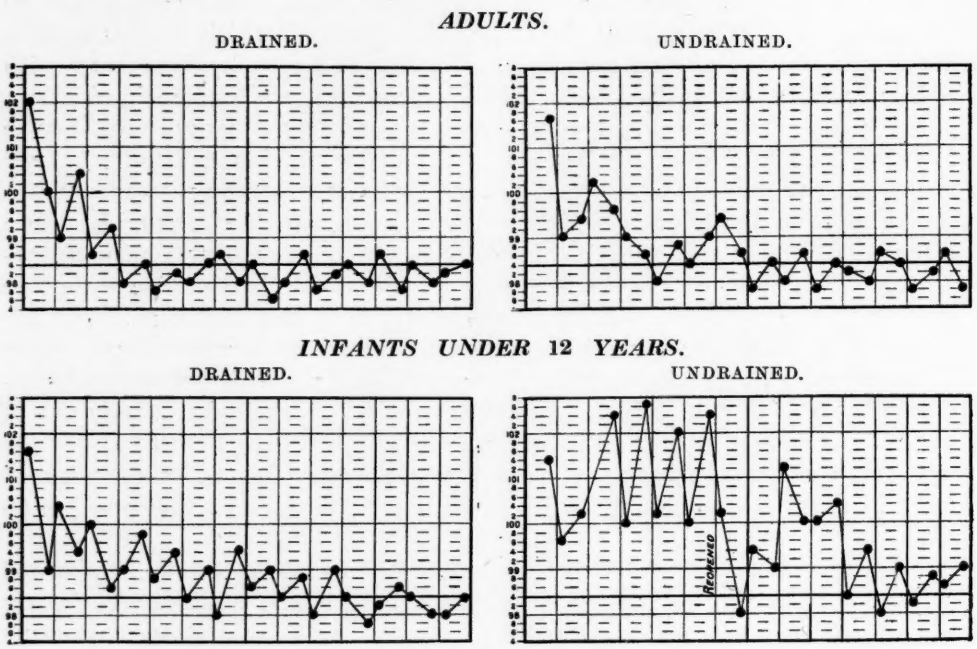

FIG. 362.—Average temperature charts obtained from a series of cases as similar as it was possible to collect.

Presence of Cyanosis.—The manifestation of a peculiar cyanosis without dyspnœa, a condition for which I cannot suggest any really feasible explanation, is another sign of advanced toxæmia. It usually foretells a rapidly fatal ending in spite of all our endeavours. Some cases, however, do recover, and this feature is a clear danger signal against the practice of closing without drainage in these instances.

The Nature of the Infecting Agent.—As a result of investigations into the particular type of organism which was responsible for the condition in many of the series, I am convinced that the isolated fact of knowing the actual infecting agent will give us little or no help in coming to a decision. In the matter of drainage, it matters not if streptococci or *B. coli communis* be the prevailing organism. The important factor is the way in which the patient is able to cope with his infection. The lack of such powers, which

is all-important for us to know, is manifested in other ways, and it is to these features we have to pay particular attention.

The Condition of the Peritoneal Exudate.—I have spoken in the earlier part of the paper of a prevailing obsession that an exudate with a purulent appearance is pus demanding drainage. The drainage of a pus-containing cavity is demanded, not by the fluid it contains, which we can evacuate by surgical means, but by the condition of the walls of that cavity, which we know will ooze further pus after we have dealt with it. It is exactly this principle which binds with equal force in the case of the peritoneal cavity. How far, then, can the character of the fluid we find be depended on to guide us as to whether more pus will come from the peritoneal membrane or not? Wilkie[12] holds that an immediate examination of the fluid will give us the necessary information which will enable us to come to a decision. He claims that the lack of large mononuclear cells, their failing power for absorbing stains, and the absence of phagocytosis are evidence that drainage is required. From my own observations on repeating his work in many of the cases here recorded, I have come to the conclusion that such features are of the utmost value in prognosis. If those three characteristics are definitely present, the case is beyond all our surgical aid. Death will ensue in a short time whether we drain or not. This view is, I think, also borne out by the cases which Wilkie reports in his paper. Carslaw[13] started some investigations with the primary object of ascertaining the relation of the exudate to drainage. In his conclusions he points out the prognostic value of such examination, but maintains that its value in deciding for or against drainage is greatly modified by the frequent demand for local drainage, and the impossibility of effectually draining the general peritoneum. Wilenski,[14] of the Mount Sinai Hospital, has recently published a paper in which he contends that the question can be settled by the number of organisms per microscopic field in a film of the exudate. He shows that, in the type of case embraced by *Class B*, few or no bacteria are seen in film in such exudates. This is the experience of all who have so examined these cases. He has, in consequence, closed all patients of this type, as I have, without any untoward results. Then his logic somewhat fails. He now reports that films from cases of gangrenous appendicitis with diffuse peritonitis contain numbers of bacteria. In such cases he simply declares that drainage was frankly indicated. He has taken them as his controls, and has not attempted to close them, so that he might really test the correctness of his contention.

It is the fluid in this latter type of case to which I have paid special attention. As a result of comparing the number of organisms seen with the after-histories of drained and undrained cases, I am convinced that this factor is of no more value to us than is the knowledge of the actual type of organism responsible. The same applies to the type of cell seen. There is, I believe, no value in, or need for, such immediate microscopic examination of the fluid in enabling us to come to a decision. The gross naked-eye characteristics of the exudate are quite sufficient for the surgeon to rely upon.

In the first place, the quantity of fluid present carries great weight. It can be taken as a good rule that the greater the amount found, the safer it is to close without drainage, provided that the exudate, however purulent

it may be, is homogeneous in appearance. A gangrenous appendix with a dry peritonitis of the diffuse variety requires drainage, since the toxins have not been diluted and their power of damage to the endothelium is mostly unimpaired. The presence of a blood-stained purulent exudate, even though copious, calls for drainage. The hæmorrhage is the result of capillary damage and subsequent loss of epithelium. I have stipulated that the fluid should be homogeneous. The abundance of definite flakes of coagulated lymph, which are largely composed of agglutinated leucocytes, is another indication for drainage. The production of experimental peritonitis in animals is greatly facilitated by the presence of gross foreign particles. This explains the reason why cases with false membranes continue to form and ooze pus after the removal of the appendix.

An exudate which has been described as having the appearance of beef-tea precludes closure with any degree of safety. The majority of such cases succumb, but in free outlet lies their only hope of recovery. Apart from these conditions, the presence of a purulent peritonitis does not of itself demand drainage.

What now is the correct procedure with regard to the removal or otherwise of the exudate in these cases of gangrenous appendicitis? To me, it is material which has done its work and has to be absorbed by the peritoneum. I personally would remove it by some method of siphonage in all cases. I have been still more convinced of the correctness of this procedure by reading the reports of cases in the early days of abdominal section. The oft-repeated improvement for two or three days after simple incision and evacuation of the purulent exudate is remarkable; so much so that I believe that if we remove this fluid at operation we lift a considerable load from the shoulders of the patient in his work of recovery. This clinical observation outweighs in my mind any theoretical evidence as to the presence of antibodies, which is sometimes put forward as an argument for leaving such exudate untouched.

The Condition of Appendix, Cæcum, and Intestines.—The degree of gangrene or perforation of the appendix matters little in the question of drainage, provided that this organ is lying free within the peritoneal cavity. If it is bound down by adhesions or is extraperitoneal, a raw infected surface of connective tissue is left which demands local drainage. It is useless and pathologically unsound to close this area in by approximating the edges with sutures, in view of the infection present. It is simply sewing up a wound which we know is contaminated with virulent micro-organisms. Any signs of extensive thrombosis or threatened gangrene of cæcum or intestine has a bearing in the same direction. The presence of marked œdema of these parts, as evidenced by definite thickening of their walls or roughening of their peritoneal surface, gives grave warning that closure may lay up serious trouble for us during ensuing days. There are cases, fortunately rare, in which the whole of the intestines and omentum present a peculiar cyanosed appearance as if stained by the products of a hæmolytic process. To close such cases is to court disaster.

The Appearance of the Omentum.—One of the chief functions of this 'policeman of the abdomen' in cases of diffuse peritonitis is to pick up and ingest organisms free in the exudate. If marked thrombosis is evident, or

if the surface is covered with an abundance of coagulated lymph, this faculty is greatly impaired, and in consequence delayed abscess formation is prone to take place if drainage is not employed under these conditions.

THE RELATION OF OPERATIVE TECHNIQUE TO DRAINAGE.

One of the greatest stumbling-blocks to the successful elimination of drainage is the practice of attempting to deliver the appendix outside the abdominal incision before removal. If the appendix is adherent to surrounding structures, it should be removed by what is called retrograde appendicectomy. If the start is made at the attachment to the cæcum, the appendix can be removed under vision with the minimum of damage. The art of gentleness thus practised in this operation will considerably increase the percentage of cases which it is safe to close.

METHODS OF DRAINAGE.

The types of drainage which we have at our disposal fall under three headings: (1) *Local drainage*; (2) *Pelvic drainage*; (3) *The safety-valve drain.* In all instances the material used is rubber tubing. What are the conditions under which each should be used?

Local Drainage.—This is called for where the invagination of the appendix stump is insecure, where a subsequent fæcal fistula is feared, for local oozing, and for the drainage of an abscess cavity shut off from the general peritoneum.

Pelvic Drainage.—The general use of this procedure was the outcome of what is always spoken of as Fowler's position. It is not within the limits of my subject to discuss how far this position does really allow of gravitation of fluid to the pelvis; but, apart from such questions, there are, I believe, other very strong factors against the use of such a method of drainage. A rubber tube in the peritoneal cavity is shut off by adhesions within a few hours. It merely serves to extraperitonealize a certain area with which it is in contact. It is often used in a case of diffuse peritonitis. Now it can only drain a very limited area of the pelvis at the best. What happens to the rest of the infected area? It obviously takes care of itself and recovers without drainage. It is reasonable to argue that the whole area could have reacted in the same way without the use of a tube at all. The only indication for the use of a drain to the pouch of Douglas is the presence of an abscess cavity in that situation at the time of operation.

Safety-valve Drainage.—I have pointed out that cases which are closed when a potential abscess is present ooze pus from a large area of peritoneum. These cases simply require what I have called a safety-valve outlet through which such pus can find its way if formed. This can be provided by passing a tube just through the incision in the parietal peritoneum. Such procedure is all-sufficient, and is devoid of all the disadvantages of a pelvic drainage tube.

The list of features which call for drainage must appear somewhat lengthy, so much so that at first sight it would seem to nullify the aim of my

paper, which is clearly to advocate a more general practice of primary closure of the peritoneal cavity in this disease. In actual practice it will be found that the result of following such procedure as I have formulated is that almost all cases of adults can be closed without drainage, but children should be drained by means of the safety-valve tube.

THE TREATMENT OF THE ABDOMINAL WALL.

Though we may close the peritoneum in the vast majority of such cases with a safe conscience, we shall court disaster if we attempt so to deal with the incision in the abdominal wall. Skin edges when brought into close and careful apposition become firmly sealed in quite a short space of time. In consequence a diffuse cellulitis of the layers of the abdominal wall develops beneath. In some cases nothing more serious occurs than a severe disappointment to both patient and surgeon when the wound completely breaks down at the end of a few days, discharging a considerable amount of pus. In others a state of affairs which endangers the patient's life is the result. The cellulitis tracks down the inguinal canal to the scrotum or labium, or more commonly round to the tissues of the loin. In three cases of this series death resulted from a streptococcal cellulitis of the abdominal wall after closure, where the peritoneum had adequately dealt with its portion of the infection. The French explain such suppuration of the wound as due to the catgut, which they hold acts as does the injection of turpentine in the formation of a fixation abscess. The discarding of buried sutures and the fixation of skin and fascial planes by figure-of-8 silkworm-gut sutures has in my experience made no difference in the frequency of such suppuration. The use of rubber dams, carbolized vaseline, and other antiseptics has likewise failed. The greatest measure of success in preserving the integrity of the abdominal incision can, I am sure, be ensured by a method of draining each layer of the abdominal wall which was described by Eisendrath[15] (*Figs.* 363–7). I have had copies made from the illustrations from his article, and am convinced of the efficacy of this form of treatment. By a series of rubber tubes he provides drainage for each layer of the incision, as can be seen from the sketches. These are left in till the stitches are removed, and both taken out together. In the cases in which I have employed it, I have utilized thin stitch tubing, and by splitting one tube longitudinally have placed half above and half below the external oblique, thus doing away with the twisted strand of salmon gut.

Another important factor in the prevention of breaking down of the wound is to remove any suture the instant that the patient experiences the slightest itching in its neighbourhood. Such a simple procedure, if acted on, will preserve intact scores of wounds which would otherwise completely break down.

At the beginning of the lecture I pointed out that in the study of disease the solution of one problem is merely the prelude to the appearance of a further riddle, which arises directly from the previous successful answer. I do not claim to have given a complete answer to the problem of drainage in

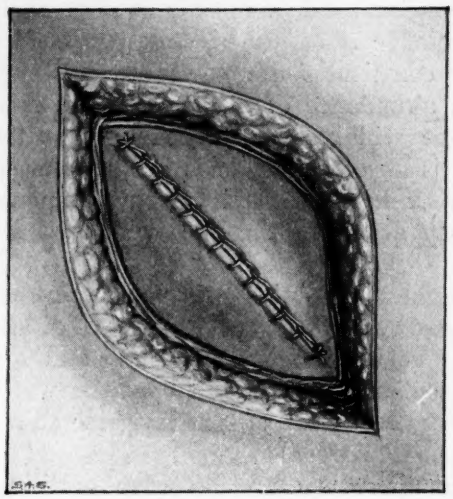

FIG. 363.—Parietal peritoneum completely closed by primary suture. (*Figs.* 363–367 *are after Eisendrath.*)

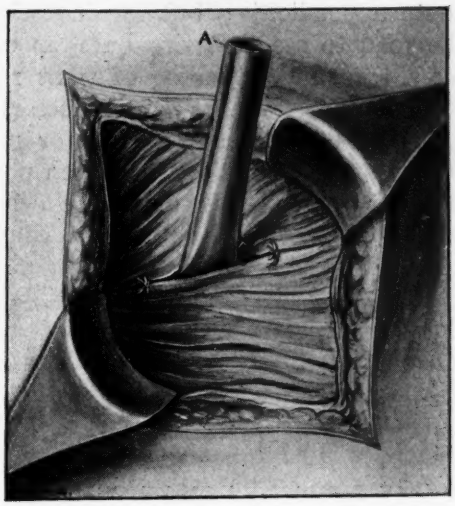

FIG. 364.—A, Tube down to peritoneum.

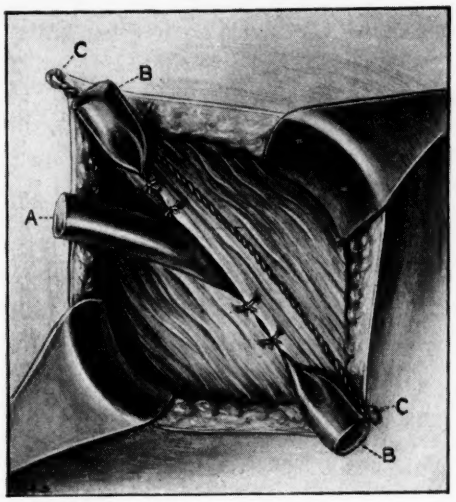

FIG. 365.—B, Tube lying below external oblique; C, Strand of twisted silkworm gut above external oblique.

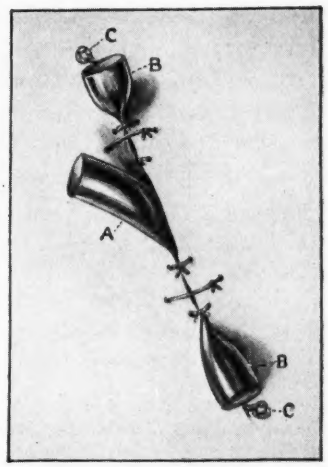

FIG. 366.—Skin incision closed, showing arrangement of drains.

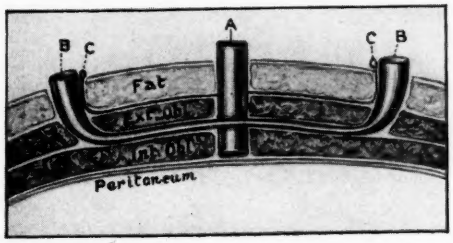

FIG. 367.—Diagram showing that each layer of the abdominal wall is provided with an outlet.

acute appendicitis; but my investigations have taken me far enough along the road to see that this question of drainage can only be definitely settled by a true understanding of what really constitutes the power of resistance to infection. If a patient possesses an abundance of such resistance, it is immaterial whether we drain or not—he will recover without giving the surgeon undue anxiety. If such power is absent, trouble is in store for us whether we close or drain. Until further light is shed on this immense field for research, I believe we can safely act upon the lines which I have indicated.

If we so attempt to deal with the problem of drainage in acute appendicitis, we shall lose that feeling of suspicious awe on hearing that cases of diffuse purulent peritonitis from this cause are closed without drainage, and our outlook towards this branch of surgery will best be described by the words of the prophet of old: "Why then is not the wound of the daughter of my people closed?"

To those who still think that a gangrenous appendix with a diffuse purulent exudate is a condition which always demands drainage, I would venture to repeat some advice given many years ago by him whose name this lectureship bears. Apt as such advice was then, it still remains so, and will be for all time: "Do not think, but try"; and in so trying, I can fully assure you that you will not suffer disappointment.

In conclusion, I wish to express my thanks to the surgical staff of the Royal Infirmary, Sheffield, for kindly allowing me to use their cases, but more especially to Professor Connell, whose practice of general closure of abdomens after appendicectomy really first stimulated my interest in this question.

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BLOOD CHANGES ASSOCIATED WITH METASTATIC TUMOURS OF BONE.

By A. PINEY, London.

The subject of secondary carcinomatous deposits in bone has been discussed in a number of publications within the past year (Joll,[1] Piney[2]), but these papers have dealt mainly with the local manifestations of the condition and with the mechanism by which the deposits are conveyed to the bone-marrow. No interest appears to have been aroused in the changes in the composition of the blood which might be expected to result from the lodgement and growth of a tumour mass in the midst of hæmatopoietic tissue.

The literature of medicine and hæmatology contains a number of reports of cases of secondary carcinoma of bone, and in a few of these the condition of the blood is recorded. In 1878 Ehrlich[3] recorded a case of 'pernicious anæmia' developing in a patient who was affected by a malignant tumour of bone (probably a sarcoma), and this appears to be the first case of 'metastatic anæmia' which is available in the literature. One of the early records which contains a detailed hæmatological report is that of Harrington and Teacher.[4] Their case was that of a woman who was suffering from latent carcinoma of the stomach and whose blood showed :—

Red corpuscles ..	1,600,000 per c.mm.	Colour index	1·09
Hæmoglobin	35 per cent	Leucocytes	14,000 per c.mm.

Myelocytes formed 0·5 per cent of the total leucocytes at the time of this examination, but at a later date the colour index had fallen to 0·9 and the percentage of myelocytes had risen to 5. Nucleated red cells were numerous, both large and small forms being seen. The peculiar blood picture was discovered about three weeks before death.

Harrington and Kennedy[5] also described a case of carcinoma of the stomach with similar changes in the composition of the blood picture, but this case differed from that of Harrington and Teacher in that the diagnosis of carcinoma of the stomach was obvious on clinical evidence, while in the former case the primary growth gave rise to no very suggestive symptoms. Ward[6] has recorded a case with similar grave alterations in the blood picture in a woman suffering from recurrent carcinoma of the breast. Unfortunately the diagnosis of secondary carcinoma of bones could not be confirmed, as an autopsy was not permitted. The colour index in this case was below unity. Parmentier and Chabrol[7] have also recorded cases in which the metastases were secondary to carcinoma of the stomach. Eosinophilia was present in their cases. Epstein[8] has presented a detailed report of the hæmatological findings in a case in which the primary carcinoma was in the mammary gland. Reichmann's[9] case was secondary to a carcinoma of the œsophagus and showed a low colour index although all the other typical features were present.

Schleip[10] reported a series of three cases in which the primary foci were in the jaw, the stomach, and the appendix respectively. Kurpjuweit[11] has also reported several cases of this type in which the alterations in the blood picture were distinctive. It will be noted that the characteristics of the blood picture as detailed by these authors show some resemblance to those of pernicious anæmia, but there is invariably leucocytosis and there is no lymphocytosis, either relative or absolute.

The case reported by Bizzarri[12] showed changes more reminiscent of leukæmia than of pernicious anæmia, thus :—

Red corpuscles ..	1,200,000 per c.mm.	Leucocytes	13,300 per c.mm.
Hæmoglobin	15 (Fleischl)	Nucleated red cells ..	24,700 per c.mm.
Colour index	0·62		

A differential count of the leucocytes showed :—

Myeloblasts	13 per cent	Eosinophils	1 per cent
Promyelocytes	9 ,,	Lymphocytes	20 ,,
Myelocytes	7 ,,	Hyalines	6 ,,
Metamyelocytes and polymorphonuclears ..	41 ,,		

The error in the total occurs in the original paper.

In this case the primary growth was in the stomach, and was a carcinoma. So striking is this blood picture that one might be tempted to consider the possibility of the occurrence of leukæmia and carcinoma of the stomach with bone metastases in the same patient; but another case has been recorded in the literature, and one will be presented later in this paper, in which a somewhat similar change occurred and leukæmia could be excluded with certainty at autopsy.

The few cases which have been thus reviewed will suffice to demonstrate that 'metastatic anæmia' is a well-defined condition. Other authors who have recorded cases and discussed the matter are Cantieri,[13] Ferrata and Negreiros-Rinaldi,[14] Luzzatto,[15] Rotky,[16] and Hirschfeld.[17]

The present writer wishes to record and discuss three cases which present features of interest in this connection.

Case 1.—The patient was a man, age 58, who had been failing in health for about three months, although he could not describe any definite symptoms. The only clinical finding was extreme pallor of the skin and mucosæ.

Examination of the blood showed :—

Red corpuselcs ..	1,200,000 per c.mm.	Colour index	0·6
Hæmoglobin	15 per cent	Leucocytes	30,000 per c.mm.

Enumeration of the different types of leucocytes in stained films showed :—

Neutrophil polymorphonuclears	47·5 per cent	Myeloblasts	5·0 per cent
Neutrophil metamyelocytes	12·0 ,,	Lymphocytes	17·5 ,,
Neutrophil myelocytes ..	12·5 ,,	Large lymphocytes	4·0 ,,
		Hyalines	1·5 ,,

The stained red corpuscles showed poikilocytosis, anisocytosis, and polychromatophilia. While counting 1000 leucocytes 2830 nucleated red cells were seen. The nucleated red cells were all of the normoblastic type, although 980 were large and polychromatophilic (macroblasts).

At the post-mortem examination an ulcero-carcinoma of the stomach was found with metastases in the regional lymphatic glands in both humeri and both femora

as well as in the vertebral column. *Fig.* 368 shows the appearance of the right humerus on longitudinal section. On histological examination the tumour was found to be a scirrhous carcinoma, and the deposits in the marrow were of the same type, although there was less fibrous tissue than in the primary growth. Plugs of tumour cells were seen lying in the blood channels (*Fig.* 369).

Case 2.—The patient was a man, age 50, who had been failing in health for about six months, at which time he was recovering from an attack of pleurisy. He complained of pain over the lumbar region of the vertebral column and had been losing weight rapidly. A mass of soft tissue was felt attached to the sixth rib on the left side. Examination of the blood showed :—

Red corpuscles	5,984,000 per c.mm.
Hæmoglobin	78 per cent
Colour index	0·65
Leucocytes	8,600 per c.mm.

A differential count of the stained leucocytes showed :—

Neutrophil polymorphonuclears	77 per cent
Eosinophil polymorphonuclears	1 ,,
Neutrophil myelocytes	5 ,,
Myeloblasts	0·6 ,,
Neutrophil metamyelocytes	3 ,,
Lymphocytes	7·4 ,,
Large lymphocytes	1 ,,
Hyalines	5 ,,

The stained red cells showed poikilocytosis, anisocytosis, and very slight polychromatophilia. While counting 1000 leucocytes 4 nucleated red cells of normoblastic type were seen.

A second examination of the blood was made a few hours before death, but only sufficient blood for the preparation of films could be obtained. The composition of the blood picture was practically identical with that found at the first examination, with the one difference that nucleated red cells were more numerous, 57 being seen while counting 1000 leucocytes. At autopsy the primary growth was found in the lower lobe of the left lung, and metastases were found in the humeri, femora, and vertebral column. Histologically the tumour was a spindle-celled sarcoma, and the deposits in the marrow (*Fig.* 370) were of the same type.

This case illustrates a type of blood change dependent upon the presence of a secondary deposit of sarcoma in the bone-marrow, and it will be noted that the changes are of the same character as those due to carcinomatous deposits. Cases in which the blood has been investigated in this condition are not numerous in the literature, but the case of Dieballa and Entz,[18] which was described in detail, is of this type. It was a spindle-celled sarcoma of the pleura in a girl, age 15. At autopsy, metastases were found in the humeri and

FIG. 368.—*Case* 1. Section of humerus showing metastases in the hyperplastic red marrow No invasion of bone is seen.

in the upper third of the femora. The blood picture in the case presented very unusual features :—

Red corpuscles ..	2,608,000 per c.mm.	Colour index	0·78
Hæmoglobin	41 per cent	Leucocytes	112,600 per c.mm.

The differential count of the leucocytes showed :—

Neutrophil polymorphonuclears	82·8 per cent	Lymphocytes	3·6 per cent
Eosinophil polymorphnuclears	0·7 ,,	Neutrophil myelocytes ..	9·8 ,,
Basophil leucocytes ..	0·2 ,,	Eosinophil myelocytes ..	0·25 ,,
Hyalines	2·3 ,,	Myeloblasts	0·1 ,,

The error in the total occurs in the original paper.

In each c.mm. of blood 300 nucleated red cells of normoblastic type were found.

FIG. 369.—*Case* 1. Section of metastases in marrow. A plug of tumour cells is seen lying in a blood channel.

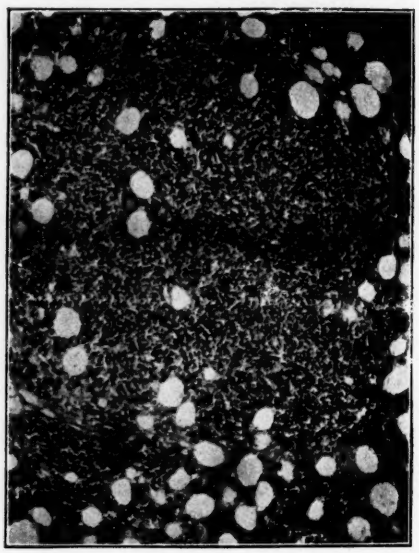

FIG. 370.—*Case* 2. Section of metastases in marrow, showing the spindle-cell character of the tumour and the diffuse growth in the marrow.

The authors conclude that the presence of a considerable percentage of myelocytes in the blood in cases of malignant tumours is highly suggestive of the presence of metastases in bones.

Case 3 does not require detailed consideration, as it has been carefully reported by Broster[19] from this laboratory. The tumour was a secondary hypernephroma situated in the femur. The blood was not examined until the day after amputation of the leg had been performed, when 0·5 per cent of myelocytes and 1·5 per cent of myeloblasts were found. There was practically no anæmia. Broster publishes a photomicrograph which demonstrates the intravascular situation of the metastases in the marrow.

Two main points which emerge from consideration of these cases are : (1) The changes in the composition of the blood do not depend upon the site

of the primary tumour; and (2) The type of primary tumour is not of material importance.

Deposits of lymphadenomatous tissue in the marrow may also give rise to similar changes in the composition of the blood.

A man, age 40, had suffered from Hodgkin's disease for some years before death, and examination of the blood at intervals during the last few months of his life showed :—

Red corpuscles ..	4,650,000 per c.mm.	Colour index	0·97
Hæmoglobin	90 per cent	Leucocytes	45,000 per c.mm.

A differential count of the leucocytes showed :—

Neutrophil polymorphonuclears	75 per cent	Lymphocytes	6 per cent
Myeloblasts	15 „	Neutrophil myelocytes ..	4 „

At autopsy the ordinary changes of lymphadenoma were found, and deposits in the marrow of the long bones were numerous. These deposits were confined to the long bones and vertebræ, in all of which the formative marrow was extremely hyperplastic. The diagnosis was confirmed by histological examination. This case of lymphadenoma shows clearly that the alterations in the blood picture do not necessarily depend upon the presence of a true tumour, but entirely upon the reaction of the hæmatopoietic marrow. The dependence upon this reactive capacity of the marrow is well shown in the case of carcinoma of the stomach with bone metastases reported by Middleton,[20] as in this case there was no specific alteration in the composition of the blood picture, and the red marrow was not increased in extent. It is obvious that the reactivity of the marrow is essential for the production of this peculiar blood picture, as is emphatically pointed out by Naegeli ;[21] but in *Case* 2 of the present series there was a comparatively small amount of functional myeloid tissue remaining, much of it having undergone an extreme degree of gelatinous degeneration.

Discussion.—It will at once be noticed that the characters of the blood picture somewhat resemble those of pernicious anæmia, but the occasional occurrence of a low colour index is of great assistance in diagnosis. The invariable occurrence of a granulocytic leucocytosis is strong evidence against the presence of pernicious anæmia, as a relative lymphocytosis is the rule in developed cases of that disease. Anisocytosis occurs both in metastatic anæmia and in pernicious anæmia, but in the former condition the large non-nucleated red corpuscles are always pale and usually polychromatophilic (macrocytes), whereas in pernicious anæmia the majority of the large corpuscles are orthochromasic (megalocytes).

In conformity with this difference between the non-nucleated corpuscles there is a difference between the nucleated forms in the two diseases. Large nucleated red cells may occur in both conditions, but in metastatic carcinoma they are always pale and usually polychromatophilic and have the normoblastic (cart-wheel) type of nucleus (macroblasts), whereas in pernicious anæmia large orthochromasic nucleated cells are the rule, and these have

finely reticular nuclei (megaloblasts). The megaloblast corresponds to the type of nucleated red cell found in the early embryo, while the macroblast appears during later embryonic life and is to be regarded as an immature normoblast. In brief, the blood picture in metastatic carcinoma corresponds to a late embryonic type of hæmatopoiesis, while in pernicious anæmia the process may be said to revert to the early embryonic type. The differential diagnosis of metastatic carcinoma from pernicious anæmia should present no difficulties if these criteria are borne in mind; but the differentiation from leukæmia may be difficult. A valuable differential point is the invariable absence of a marked increase of basophil leucocytes in metastatic anæmia, whereas this is almost invariably present in leukæmia, and the presence of even a few basophil myelocytes may be regarded as very strong evidence of the leukæmic nature of the case.

The histogenesis of the blood changes is still uncertain, but the present writer has briefly discussed this matter in a previous publication.[2] Any attempt at the explanation of the histogenesis of this blood picture must be preceded by a brief résumé of the histology and anatomy of the marrow: the normal adult has marrow in the upper ends of the proximal long bones, in the ribs, and in the vertebræ: this is described in detail elsewhere by the present writer.[22]

Histologically the marrow is built up of a series of thin-walled, wide blood channels in which the blood-flow is extremely slow: between the blood channels are the parent cells of the granular series of leucocytes, while in the lumen of the channels the process of erythropoiesis takes place. This intravascular erythropoiesis occurs both in the adult and in the embryo, as has been shown by Dantschakoff.[23]

No lymphatic channels have been demonstrated in the marrow of man or any other animal. The periosteum of the affected bones in the present series of cases was carefully searched for evidence of permeation, but no signs could be found: this also applies to a previous series of cases which the present writer has published,[2] and in Broster's case no signs of periosteal involvement could be found.

The inevitable conclusion is that metastatic deposits in the bone-marrow are blood-borne and are therefore intravascular in position, as the author has demonstrated,[2] and these conclusions are in conformity with the findings of Deelmann,[24] Broster,[19] Joll,[1] and many others.

If this intravascular position of the metastases be accepted it will be obvious that the first irritative effect of such deposits will be exerted upon the intravascular erythroblasts; but at a later stage, when the emboli have grown into the surrounding leucopoietic tissue, there will also be severe irritation of the leucopoietic mechanism.

The fact that secondary sarcomata of bone may give rise to a blood picture identical with that caused by metastatic carcinoma is difficult to explain unless the hæmatogenous origin of carcinomatous bone metastases be accepted. The hæmatogenous spread of sarcoma is universally accepted, and it is unnecessary to postulate any other mechanism for the explanation of the blood picture in secondary carcinoma.

SUMMARY.

1. A specific type of blood picture is described which depends upon the irritation of the marrow by secondary deposits of tumours or granulomata.

2. The characters of the blood picture may be roughly divided into two main classes, namely, those of the pseudo-pernicious and those of the pseudo-leukæmic type.

3. The hæmatogenous origin of marrow metastases is re-affirmed.

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CYSTIC PNEUMATOSIS OF THE INTESTINAL TRACT.

By CYRIL A. R. NITCH, London.

(Presidential Address delivered before the Section of Surgery of the Royal Society of Medicine in November, 1923.)

The full and Continental name for this remarkable pathological condition is *pneumatosis cystoides intestini hominis*. The two cases on which this paper is based have already been recorded by Professor Shattock and myself in the Proceedings of the Section of Pathology of the Royal Society of Medicine for 1919; but as the annual output of medical literature is so vast that the practical surgeon cannot keep pace with it, I have ventured to refer to them again.

Fig. 371.—*Case* 1. Portion of the small intestine as it appeared when exposed, showing numerous gas blebs projecting beneath the peritoneum. Redrawn from a sketch made whilst the gut was exposed during life. (Natural size.)

Case 1.—A schoolmaster, age 48, who had suffered for fifteen years from troublesome flatulence and recurring attacks of epigastric pain about one and a half hours after food. The attacks lasted for a month or more, and the pain, which at times was very severe, was always relieved by vomiting. In 1912 the pain became almost continuous, and was accompanied by abdominal distention and increase of flatulence. On the advice of his doctor he consulted Dr. A. E. Russell, who diagnosed pyloric stenosis secondary to ulceration, and advised an operation. As the patient refused surgical treatment, his doctor taught him to wash out his stomach with a rubber tube, and this he carried out daily for six years. The lavage conferred relief, but, as might be expected, he became so weak and emaciated that in June, 1918, he only weighed 7½ stone. He was then persuaded to submit to an operation, and entered St. Thomas's Hospital on June 29, 1918. He was very weak and thin. His stomach was so greatly dilated that its lower border was level with the crest of the ilium. There was moderate gastric peristalsis. I operated upon him on July 3, and found an extreme degree of stenosis of the pylorus, for which a posterior no-loop gastrojejunostomy was performed. On drawing up the great omentum to prepare the field for the anastomosis, a coil of small intestine, studded with greyish-white glistening elevations, presented in the wound (*Fig.* 371). On closer examination these proved to be multilocular subperitoneal cysts, varying in size from a pin's head to a pea, and on puncturing one of them I was astonished to find

that the contents were gaseous and not fluid. The cysts were dotted more or less evenly over the whole circumference of the bowel, and there were also a few, about twice the size of a pin's head, in the transverse mesocolon and at the base of some of the appendices epiploicæ. With the exception of the first 12 inches of the jejunum and the last 12 inches of the ileum, the whole length of the small intestine was affected. The freedom of the first part of the jejunum was fortunate, as otherwise an anastomosis would have been attended with grave danger of leakage, owing to the multiplicity of the cysts. The mesentery of the small intestine, and the walls of the stomach, duodenum, and colon, were normal. The patient made an uninterrupted recovery. Two and a half months later, though he still had occasional flatulence, it caused him neither pain nor inconvenience. His bowels acted regularly without an aperient; he had gained 2 stone in weight and resumed his work. Three weeks ago, in answer to a letter, he stated that there had not been any recurrence of symptoms and that he was quite well.

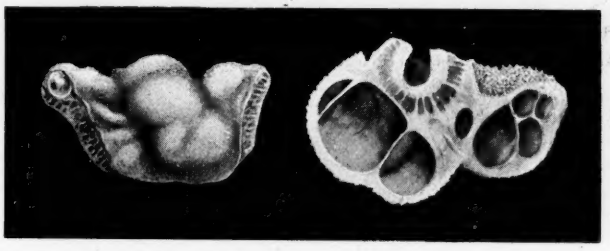

FIG. 372.—*Case* 1. A, A narrow piece of the small intestine, excised during life, viewed from the inner aspect. The mucous membrane is raised in hemispherical eminences by the presence of gas in the submucosa. At each end a portion of portion of the divided muscular coat is shown. (Natural size.) B. A section made through a portion of the same piece of small intestine, showing the multiple cavities beneath the mucosa; the muscular coat is recognizable at the top of the specimen. (Twice natural size.)

For the purpose of investigation a V-shaped piece of the intestine was excised transversely to its long axis so as to leave the mesenteric border intact, the gap being closed with a continuous silk suture (*Fig.* 372). It was sent immediately to Professor Shattock, who reported that:—

"Its mucous membrane was raised in rounded, confluent elevations, obviously filled with gas. On the peritoneal aspect the intestine at the particular spot was normal, although at first sight the thinness and translucency of the wall led to the belief that the gas cysts were beneath the peritoneum."

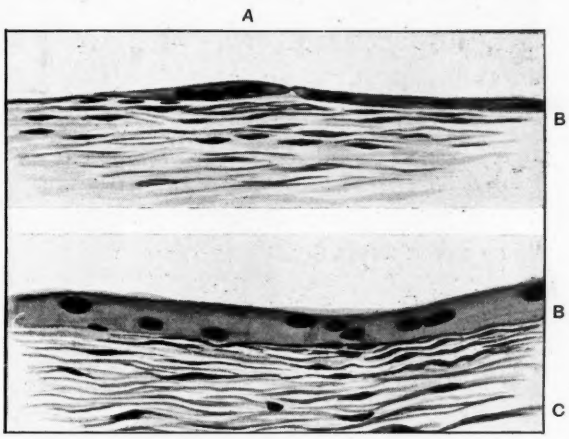

FIG. 373.—*Case* 1. Microscopic sections showing the endothelial lining of the cysts. In the upper it is thinner than in the lower, and includes a flattened multinucleated cell. The histological signs of inflammation are quite absent. A, Giant cell. B, Endothelium. C, Normal connective tissue. ($\frac{1}{8}$ obj.)

(It should be noted that Professor Shattock describes a normal peritoneal covering and *submucous* cysts, whereas the portion of bowel selected for excision was studded with *subperitoneal* cysts. The change in the location of the cysts must have been due to the hardening agent, which caused the intestine to curl up and thus drove all the subperitoneal gas into the submucous cavities).

"HISTOLOGY (*Fig.* 373).—Sections cut in paraffin and stained with Ehrlich's hæmatoxylin and eosin yield the following results: The walls of the spaces, which are limited to the submucosa, consist of ordinary connective tissue in which there is

an utter absence of small-celled infiltration or of any of the marks of inflammation. Their inner surface is lined with a simple endothelium, which is most satisfactorily seen when part of the trabecula is viewed on the flat; the cells form an extremely thin, continuous mosaic, and are furnished with large oval nuclei of the usual type. Here and there a flattened, multinucleated giant cell is intercalated between them. In the connective tissue of the submucosa in the neighbourhood of the cysts, and between the layers of muscle, the strands of sympathetic fibres and the nerve-cells of Meissner's and Auerbach's plexuses are particularly distinct and normal. Both the mucosa and the muscular wall are quite intact. Certain of the spaces have a thin wall of connective tissue differentiated from that around by its concentric disposition. The presence of so complete an endothelial lining indicates that the spaces here shown are lymphatic rather than clefts produced by the inflation of the connective tissue, the walls of which have become lined with proliferated lamellar corpuscles."

An attempt was made to ascertain the composition of the gas, but the quantity obtained from the cysts was so small that analysis was impossible.

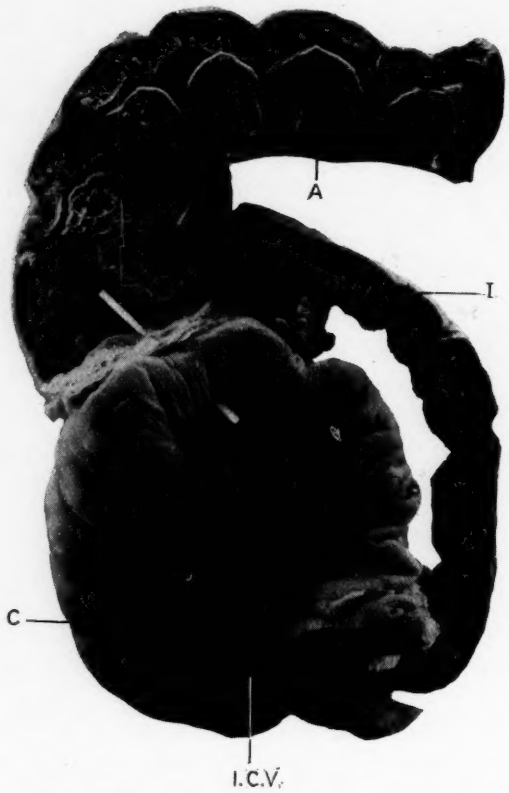

FIG. 374.—*Case* 2. Cystic pneumatosis of the cæcum and ascending colon. The cæcum has been laid open by a vertical incision; the ileum and the ascending colon have been bisected longitudinally. A, Ascending colon showing extensive submucous emphysema. C, Cæcum much thickened by gas in the submucous tissue. I.C.V., Ileocæcal valve. I, Normal ileum.

Case 2.—A woman, age 40, upon whom I operated on May 27, 1919. She was quite well until twelve days previously, when she was suddenly seized with acute colicky pain in the right iliac fossa. The pain subsided in a few hours, but recurred a week later, and gradually became more intense. There was no vomiting, and only slight constipation. Upon examination, a tender, elongated swelling was found in the right iliac fossa which stiffened and relaxed every few minutes, suggesting an intussusception. There were no signs of peritonitis; the temperature was normal; pulse 72. At the operation the walls of the cæcum and ascending colon were found inflamed, thickened, and crepitant on pressure; beads of gas, moreover, were freely distributed in the surrounding connective tissue, and in some of the appendices epiploicæ. The vermiform appendix, and termination of the ileum, were unaffected. There were several calcified tuberculous lymphatic glands in the ileal mesentery; no tubercles were seen on the peritoneum. After excision of the terminal six inches of the ileum, together with the cæcum, the ascending colon, and a third of the transverse colon, the continuity of the bowel was restored by lateral ileo-transverse colostomy. Recovery was rapid and uneventful, and she has remained well ever since.

Professor Shattock examined the specimen (*Fig.* 374)* and reported as

* This specimen is now preserved in the Museum of the Royal College of Surgeons. No. 1142.1. General Pathological Series.

follows: "On slitting up the cæcum its walls were found thickened throughout from submucous emphysema, the ileocæcal valve being also involved; the mucosa of the latter was deeply congested, but without ulceration. There was a second patch of congestion, about the size of a sixpence, at the upper part of the cæcum. The connective tissue and appertaining fat about the cæcum and ascending colon contained large numbers of gas blebs, ranging from a minute size to that of a pea. After the parts had been hardened in formol solution, the examination was completed. The termination of the small intestine was divided longitudinally, the incision being carried through the valve into the cæcum; it is remarkably contracted, its mucosa being thrown into regular, closely set, circular folds like valvulæ conniventes. Its walls are quite free of gas; no ulceration is discoverable; its

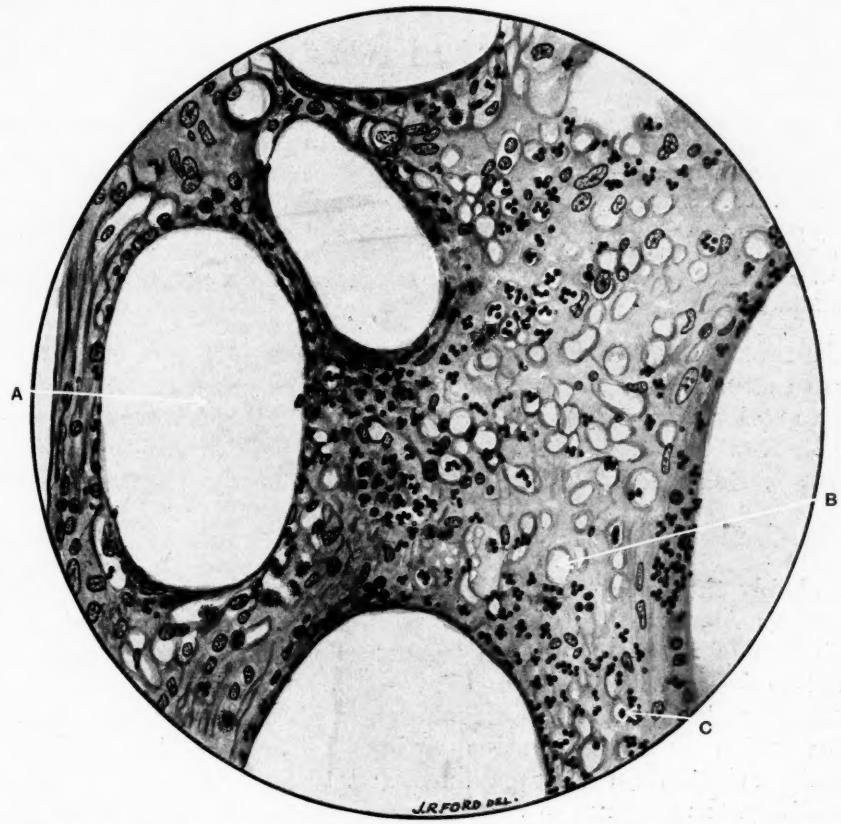

FIG. 375.—*Case* 2. A microscopic section of the emphysematous colon, showing the spaces in the submucosa. The septa are thickly infiltrated with polymorphs. In the earlier stages the formation of gas is accompanied with an exudation of serum, as may be recognized in the thickest of the trabeculæ. The section is from the neighbourhood of the most distal portion. ($\frac{1}{6}$ obj.). A, Large space without differentiated lining. B, Small space filled with serous exudate. C, Polymorphs.

interior contained a small amount of green, bile-stained mucus. On longitudinally bisecting the ascending colon, a remarkable condition presented itself. The mucous membrane is raised in prominent, somewhat hemispherical elevations by a diffuse submucous emphysema, the tissue being like a sponge, or a section of lung. The elevations are so prominent, and interdigitate so compactly, as to block the lumen. The line of the muscularis is straight and intact, and the mucous membrane itself is readily traceable over the cavernous areas resulting from the pneumatosis. The cæcum is similarly, though less, affected, the elevation of the mucosa being uniform

in degree, and so general that the lumen is but slightly diminished. The valve is involved in the same manner; but the condition ceases abruptly at the small intestine. The vermiform appendix, lastly, is firm, and below the normal in diameter: on longitudinal bisection it proved to be solid throughout.

"The microscopic examination of the wall of the ascending colon (*Fig.* 375) in the neighbourhood of the distal end of the emphysematous portion, shows that the mucosa with its glandular structures, as well as the muscularis, are unaffected. The vacuolation is limited to the submucous connective tissue. The smaller spaces are partly filled with homogeneous exudate containing polymorphs, large numbers of which infiltrate the septa between the lacunæ. The spaces have no differentiated lining. Sections prepared from the emphysematous ileocæcal valve exhibit similar appearances; in these there are conspicuous numbers of multinuclear giant cells in the tissue bounding the spaces.

"In this case there was no obstruction, either distal or proximal to the affected area, which might have resulted in hyperdistention and trauma of the mucosa; nor was there any ulcer the base of which might have given way and allowed of the effusion of gas. The emphysema cannot but be ascribed to an infection of the wall of the cæcum with a gas-producing bacillus, notwithstanding the failure to demonstrate the presence of such in histological sections, either in the exudate or in the cells. The histological picture is that of a somewhat acute infective process which involves not only the submucosa, but in places, the muscularis also. There are no vacuoles in the giant cells to suggest that these are gas-secreting; and it may be observed that giant-cells are not present in the proper gas-gland of the swim-bladder of fish."

The rareness of this condition is exemplified by the fact that within the last two centuries only about 90* cases have been recorded, one in Scotland (Shennan and Wilkie, 1909), four in England, including the two just described (Mair 1, Thorburn 1, Nitch and Shattock 2), four in America (Finney 1, Twyman 1, Bubis and Swanbeck 1, Sloan 1), and the remainder abroad.

HISTORICAL.

Probably the earliest known specimen is one described in the catalogue of Ruysch's Anatomical Museum in Amsterdam in 1737 as "a portion of the jejunum of a man showing a tumour which arose from wind when the external tunic was slightly injured".

Ten years later, in 1747, Combalusier, in his work on pneumatosis, cited an observation by an anonymous writer (I. G. D. — ? Duvernoy) in the Academiæ Scientiarium Petropalitanæ (St. Petersburg), Tomus v, p. 213 (1730–31), on the presence of subperitoneal and submucous collections of gas in the intestine. These swellings were "alike in number, shape, and size, some being narrow and some circular, and some projected to such an extent that they almost obliterated the lumen of the canal".

In 1756 Haller found numerous subperitoneal gas cysts on the intestines of a woman who died of tympanites. The condition apparently attracted no further notice, or was not considered worthy of comment, for 64 years, when Cloquet in 1820 reported a case of emphysema of the wall of the stomach in a male discovered a few hours after death, and Andral in 1831 drew attention to a similar condition which he had noted at autopsies performed in the summer

* The number is given at *about* 90, for though only 85 have been traced, the writer thinks some have escaped his notice.

shortly after death. Both writers realized that post-mortem decomposition might account for the emphysema, but evidently the appearance was not quite similar, for in commenting on it, they each stated that though discovered at an autopsy, it might have formed during life. They also pointed out the macroscopic resemblance between intestinal pneumatosis in man and gas cysts found in the rectum of hogs slaughtered in summer.

A somewhat similar condition known as *vaginitis emphysematosa* was first described by Ritgen in 1835, and subsequently by Winckel in 1871. It is characterized by the presence of gas cysts in the mucosa and submucosa of the upper part of the vagina, and occasionally also in the bladder, in pregnant women, or after parturition in women the subjects of gonorrhœa, and is now ascribed to infection of inflammatory nodules by a gas-forming organism, the *B. aerogenes*. Chiari, writing in 1885, connected the disease with intestinal pneumatosis. This opinion was upheld by Eppinger and Eisenlohr (1888), who found gas cysts in the intestine of a case of vaginitis emphysematosa which was examined four and a half hours after death from heart disease. Owing to the presence of groups of bacilli in the cysts, they considered that both diseases were due to bacterial infection. In view of recent research, it is probable that the bacterial infection of the intestinal cysts in these cases was post- rather than ante-mortem.

After Andral's brief communication in 1831, there does not appear to be another record of human intestinal pneumatosis until 1876, when Bang, of Copenhagen, described an undoubted case which attracted so much attention that he was erroneously credited with the discovery of the disease. At an autopsy on a woman, age 57, who died of volvulus of the sigmoid, Bang found multiple gas cysts, varying in size from a pea to a bean, in the wall of the lower two feet of the ileum. The cysts were in the submucosa and between the circular muscle fibres; they were lined with endothelium, and their walls contained numerous giant cells. He considered that they were due either to dilatation of lymphatic spaces or to a neoplasm; he called the disease *pneumatosis cystoides intestini hominis*, a name which Continental writers have retained. In a paper on cysts of the intestine published in 1882, Marchiafava described a case which in the extent and distribution of the cysts closely resembles one of mine (*Case* 1). At an autopsy after dysentery the whole of the small intestine, with the exception of the first part of the jejunum, was found to be studded with subserous gas cysts containing many multinucleated giant cells in their walls. The presence or absence of an ulcer of the stomach or intestine is not mentioned.

Up to this time all the records relate to findings at post-mortem examinations, and it was not until 1899, when abdominal surgery had become a regular procedure, that Hahn described the first case of cystic pneumatosis discovered in the living. At an operation for supposed pyloric stenosis on a male, age 35, the subject of abdominal pain and alternating constipation and diarrhœa of two years' duration, he found a large number of sessile and pedunculated gas cysts on the small and large intestine. The pylorus was said to be patent, but the stomach and ascending colon were greatly dilated.

Since then the number of recorded cases has gradually increased. Faltin, in 1914, described 55 cases, of which 33 were discovered at operation; a year

later Kuder published 62 ; in 1920 Hey, and at a later date Weil, each added 4 cases, making 70 in all, of which about two-thirds were noted at operation, and finally, after a prolonged search through a voluminous literature, I have found 15 more, bringing the total to 85. In all probability this number is fairly accurate, for these cases are so rare that they seldom escape publication.

INTESTINAL EMPHYSEMA OF SWINE.

An analogous condition called intestinal emphysema occurs in certain animals, and is similar in many respects to cystic pneumatosis of man. It is found comparatively frequently in the intestine and rectum of swine killed in the summer, and has been the subject of much investigation and argument. First noted by Andral in 1825, it was more carefully investigated in the same year by Mayer, who concluded that it was due to the mechanical escape of gas into the submucous and subserous tissues through an abrasion in the mucous membrane. In 1837, John Hunter also drew attention to the presence of gas cysts on the intestines of hogs killed in summer, and suggested that the air escaped from the blood, either from natural causes or through diseased vessels. Two of his specimens, Nos. 1141.1 and 1141.2, are in the Hunterian Collection in the Museum of the Royal College of Surgeons, and one of them, *Fig.* 376, is thus described: "A portion of the rectum of a hog, of which the peritoneal coat is in many places, and especially by the sides of the mesorectum, covered with clusters of thinly walled cysts, many of which are pedunculated; and all of which contained gas."

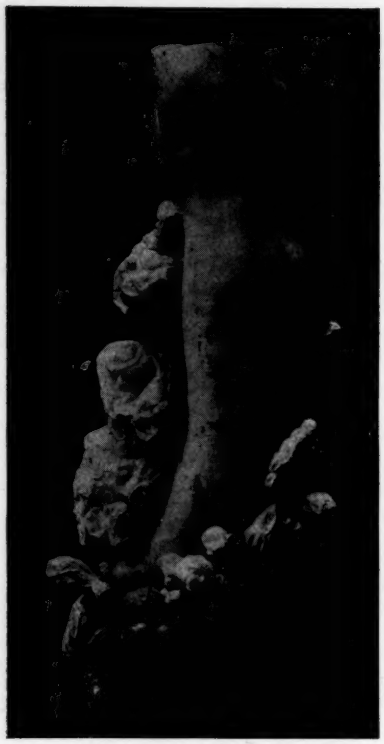

FIG. 376.—Hunterian Specimen No. 1141.1, Museum Royal College of Surgeons. Portion of hog's rectum with subperitoneal gas cysts. Many are pedunculated and also twisted on their pedicles.

This specimen is illustrated in Hunter's *Works*, where it is recorded that it was sent to him by Jenner, and that the gas in the cysts was examined by Cavendish, who found "it contained a little fixed air (carbon dioxide); and the remainder not at all inflammable (inflammable air = hydrogen) and almost completely phlogistigated" (phlogistigated air = nitrogen). Sir James Paget, commenting on this specimen in his *Letters on Surgical Pathology*, third ed., 1870, p. 402, thus eulogizes: "What a relic have we here! Surely never on an object so mean to common apprehensions, did such rays of intellectual light converge, as on these to which were addressed the frequent and inquiring observations of Jenner, the keen analysis by Cavendish, and the vast comparison and deep reflection of John Hunter! Surely never were

the elements of an inductive process combined in such perfection! Jenner to observe; Cavendish to analyse; Hunter to compare and reflect".

The first detailed description of intestinal emphysema of swine was published by Roth, who stated that both the macroscopic and the microscopic appearances were very similar to those of the human variety. Subsequently Schmutzer and Heydemann confirmed his findings and, together with Plenge, agreed with his conclusion that the gas in the cysts was intestinal in origin. This view is strongly opposed by Dupraz, Jaeger, and more recently by Joest. They consider that the gas is bacterial in origin, though they do not agree on the organism concerned in its production. Jaeger cultivated a gas-forming bacillus of the coliform group from four of his cases, which he named *B. coli lymphaticum aerogenes*, and on the basis of animal experiments concluded that the bacilli entered the submucous lymphatics through a chronically inflamed mucous membrane. Joest, in supporting this view, points out that it is impossible for intestinal gases to enter the lymphatics by intestinal pressure alone, and that, in pigs affected with emphysema, obstruction with distention of the intestines has never been observed. He refers to the frequency of the disease in dairy-fed pigs in which intestinal catarrh from an excessive carbohydrate diet is of common occurrence, and suggests that colon bacilli enter the chyle ducts through the inflamed mucous membrane, where their fermentative action on an excess of sugar leads to the formation of gas.

According to Finney, the bacterial origin of the disease in pigs was confirmed by investigations carried out in America, where a colon bacillus was isolated in every case examined. The similarity of the gas, i.e., atmospheric air in both human and animal cysts, is explained by diffusion through the cyst wall in the long interval which often elapsed between the removal of the specimen and the analysis of the gas (Jaeger).

Although intestinal emphysema in man and animals is in many ways much alike, Jaeger draws attention to dissimilarities which strongly suggest a different pathogenesis; notably, in man, pneumatosis is usually more widely distributed than in the pig, affecting the colon, cæcum, small intestine, and even the stomach, while the cysts are most numerous on the ante-mesenterial surface of the bowel. In pigs, the disease is usually limited to the jejunum, rectum, and mesentery, and the cysts are practically always situated at the attachment of the mesentery. Again, in man, pneumatosis is nearly always associated with constipation and an organic stricture of some portion of the intestinal tract, whereas, in pigs, intestinal catarrh is the only lesion that has been discovered.

After this brief digression into the realms of comparative pathology, I will return to pneumatosis of man.

PNEUMATOSIS IN MAN.

Co-existing Lesions.—As already stated, at the time of writing, records of 85 cases only have been found. In 29 the lesion was discovered at a post-mortem examination, and it is significant that in 9 of these, or 31 per cent, death was due to one of the complications of gastric or duodenal ulcer. Of the remainder, 52 were detected at an operation, and again the commonest lesion was a gastric or duodenal ulcer (34, or 65 per cent).

Therefore, in the 85 cases, 43 (50 per cent) were definitely associated with an ulcer of the stomach or duodenum, and in 36 of these (83 per cent) there was stenosis. Other co-existing lesions of importance were carcinoma of pylorus (2), tuberculous ulceration of the intestine (4), intestinal obstruction (3), tuberculous peritonitis (1), and gastro-enteritis (2). In 21, morbid changes in addition to the gas cysts were either not found or not recorded. From these figures it is evident that in a large proportion of the cases the cysts are associated with some form of obstruction of the intestinal canal: a fact which has an important bearing on their etiology.

Sex and Age.—Males are affected more often than females, in the proportion of about 3 to 1, and the age limit ranges between 13 and 60 years. In 37 cases the age incidence was as follows: 10–20, 1; 20–30, 5; 30–40, 14; 40–50, 10; 50–60, 6; 60–70, 1. Thus it is commonest in the fourth and fifth decades—the ages for *chronic* gastric and duodenal ulcers.

Situation.—In an analysis of 45 cases the lesions were distributed as follows:—

Stomach, gastro-colic and gastro-hepatic omentum (carc. pylorus) ..	1
,, jejunum, ileum, transverse and ascending colon (pyloric stenosis)	1
Pylorus only (stenosis)	1
Jejunum only (pyloric stenosis)	1
,, parietal peritoneum and diaphragm (peritonitis)	1
,, and ileum only (pyloric stenosis 3, intestinal obstruction 1) ..	4
,, ileum, great omentum, and diaphragm (pyloric stenosis) ..	1
,, ,, and great omentum (pyloric stenosis in all) ..	3
,, ,, and transverse mesocolon (pyloric stenosis) ..	1
,, ,, cæcum and ascending colon	1
,, ,, ,, ascending colon, transverse mesocolon, and great omentum	1
,, ,, ascending and transverse colon (pyloric ulcer) ..	1
Ileum only (pyloric stenosis 13, carc. pylorus 1, volv. sigmoid 1) ..	15
,, and gastro-hepatic omentum (pyloric stenosis)	1
,, and transverse mesocolon (pyloric stenosis)	1
,, and great omentum	1
,, and vagina (probably post mortem)	1
,, and cæcum	1
,, cæcum and ascending colon	1
,, ,, transverse mesocolon, and great omentum	1
,, and ascending colon (pyloric stenosis)	1
Cæcum and appendices epiploicæ	1
,, and ascending colon (pul. phthisis 1, appendicitis 1) ..	2
,, ascending colon, and appendices epiploicæ	1
Hepatic flexure (adherent to stenosed pylorus)	1

The cysts are always situated on some portion of the intestine, and most often on the ileum, particularly near its termination. The jejunum is frequently involved as well as the ileum, but it is rare to find cysts on this portion of the bowel alone. In only one instance have cysts been described on the duodenum (Kolli, quoted by Plenge); otherwise, this segment of bowel shares with the appendix and rectum a remarkable freedom. The large bowel is affected with comparative frequency, when the cyst formation appears to cease abruptly at the splenic flexure; it is seldom involved alone, being usually associated with similar lesions in the lower end of the ileum. In some instances the emphysema is limited to the cæcum and ascending colon, and in four such cases the presence of a definite tumour before operation led to a diagnosis of intussusception or appendicitis. It is noteworthy that in

three of these cases (Philip, Twyman, Nitch) there was no lesion to account for the cysts, and in the fourth (Bubis and Swanbeck) there was an ulcer at the base of the appendix. The stomach, omenta, mesentery, peritoneum, and appendices epiploicæ are rarely affected. In two cases a cluster of cysts was found on the under surface of the diaphragm (Jaboulay, and Vallas and Pinatelle); in another the mesenteric glands were distended with gas bubbles (Schnyder), and in another rows of cysts were found in the mesenteric lymphatics (Jaeger).

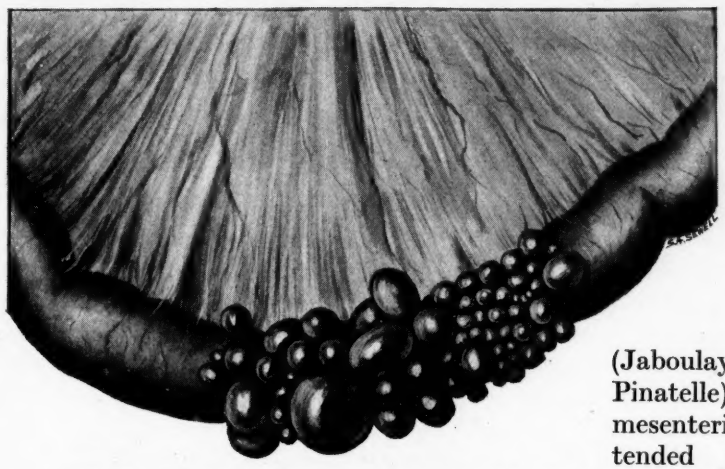

FIG. 377.—Showing clusters of gas-containing cysts on the small intestine. (From a photograph of an illustration in *Annales de Médecine*, 1920, viii, article by M. P. Weil. Illustration lent by Mauclaire.)

Though the cysts are usually situated opposite the attachment of the mesentery, they may be more or less uniformly distributed over the whole surface of the intestine, and also on the mesentery itself. As a rule they are spread over a considerable length of intestine, as in my first case; but they may occur in large or small groups separated from each other by portions of healthy bowel (*Fig.* 377). They sometimes form masses, like a collection of soap bubbles or a bunch of translucent grapes, attached to the convex surface of the intestine (*Fig.* 378), and in one case, described by Neugebauer, formed a large tumour which could be both felt and seen beneath the abdominal wall. Though usually sessile, they may possess pedicles as long as 5 cm. (Plenge) which are sometimes twisted on their long axes as in John Hunter's specimen of the hog's rectum (*Fig.* 376). As a

FIG. 378.—Sloan's case. Masses of translucent gas-containing cysts attached to the convex surface of the small intestine. (Photograph from an illustration in *Surgery, Gynecology, and Obstetrics*, 1920, xxx, 390.)

general rule the single cysts, as distinct from the massed collections, vary in size from that of a pin's head to that of a walnut, but Arzt has described one as large as an egg, and Urban one the size of a man's fist.

Small white raised papules on the surface of the intestines, probably due to collapsed cysts, have been noted by several observers (Bang, Faltin, Plenge, Winands, Urban). Curious villous tufts of uncertain origin are also sometimes present between the subserous cysts both in man and pig; they have been variously ascribed to hyperplasia of the endothelial lining of the lymphatics (Roth, Bang), and to strands of subserous connective tissue which have followed the migration of gas beneath the peritoneum (Schmutzer).

The anatomical site of the cysts of the intestine is the subserous and submucous tissues; they are seldom found in the muscular coat, and have only been seen in the mucosa on two occasions (Heydermann). Beneath the peritoneum they form oval and rounded, shiny, translucent swellings, which are occasionally globular and pedunculated; in the submucosa, owing to the thickness of the mucous membrane covering them, they are not translucent and never pedunculated. They are seldom limited to one tunic alone; in some instances the greatest number were subserous, and in others submucous. Orlandi records one case in which they had encroached on the lumen of the bowel to such an extent as to produce obstruction. They rarely communicate with each other or directly with the interior of the intestine; but Bubis and Swanbeck record the interesting observation that, in a case of emphysema of the cæcum with an ulcer at the base of the appendix, compression of the cæcum caused gas to escape through the ulcer.

In two of the cases of pneumatosis of the cæcum (Bubis and Swanbeck, and Nitch) the condition was analogous to a true surgical emphysema, for the gas, instead of forming localized collections, had permeated the tissues to such an extent as to give them the appearance of a sponge, or a section of lung. It may be mentioned here in passing, that in the writer's opinion this form of emphysema bears no relationship to the classical form of cystic pneumatosis, though it is often included in the same category.

Histology.—All writers agree as to the remarkable uniformity of the histological appearances. The wall of the cyst is always the same, consisting of ordinary connective tissue of varying thickness in which there are no signs of small-celled infiltration or inflammation (*Figs.* 373, 379). The vessels in the walls are small and few in number. Turnure, Kuder, and Urban describe a perivascular round-celled proliferation between the cysts, and Torraca noted a similar change around the lymphatics. The cysts are lined with a simple endothelium containing a varying number of multinucleated giant cells. In some sections examined by Plenge this lining membrane was covered with giant cells with pseudopodic processes which projected into the cavity of the cyst, and he also noted giant cells of uncertain origin in the intercystic connective tissue. Matronala points out that pseudopodic processes are only seen in small cysts where the gas tension is slight, and that as the walls yield to increasing pressure the giant cells become flattened and scanty and, in the largest cysts, extremely rare. Retrogression of the cyst is characterized by increase of its concentric connective tissue and progressive decrease of its lumen until it is reduced to a nodule of compact fibrous

tissue, forming the raised white papule or 'scar' so commonly seen beneath the peritoneum.

The constant presence of giant cells in the walls of the cysts has led some writers to credit them with a pathogenic rôle; thus Mair considered that by a process of vacuolation within them the nodules of dense connective tissue in which they were imbedded became hollowed out to form cysts; Shennan and Wilkie and others have suggested that they are concerned with the production of gas. In this context it should be noted that there are no giant cells in the gas-gland of the swim-bladder of fish. The fact that giant-celled formation is now well recognized by pathologists as a sign of chronicity is a sufficient and simple explanation of their presence in the cyst wall. Fissures containing gas, either with or without an endothelial lining, are occasionally found in the muscular coat; the former are due to enlargement of a lymphatic

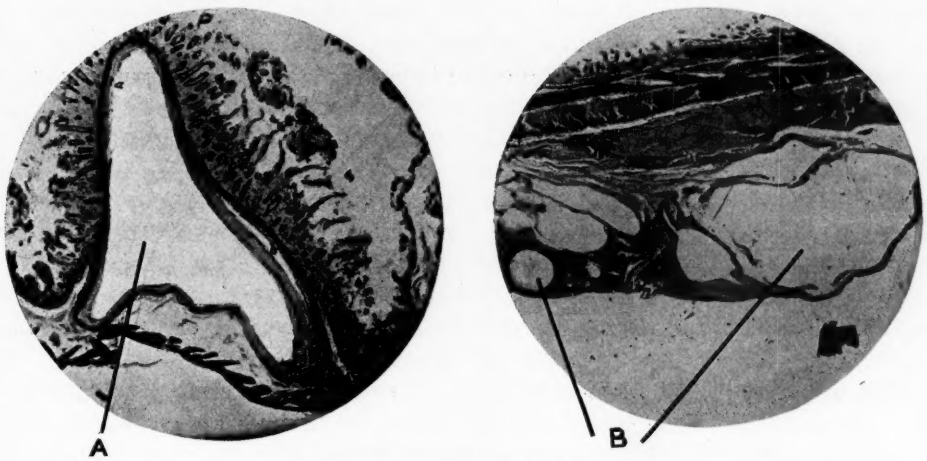

FIG. 379.—Shennan and Wilkie's case.

A, Section from upper portion of ileum with a submucous cyst projecting into lumen of bowel. It is quite separate from the muscular coats and is partly lined by flattened multinucleated cells (*a*). At (*b*) is a narrow cyst lined by similar cells. (× 18).

B, Section from lowest affected coil with cysts on the serous surface, showing a recent cyst with lining giant cells; and a fully formed cyst, with scanty flat lining cells. (× 10.)

(From the '*Journal of Pathology and Bacteriology*', 1909, xiv.)

space (Ciechanowski, Hey), and the latter to escape of gas into the surrounding connective tissue from a ruptured cyst. In rare instances the cysts contain, in addition to gas, a small quantity of serous fluid which is remarkable for its lack of cells. Gelatinous masses of blood-stained fluid of obscure origin have also been noted. A constant feature of the histological picture in a large proportion of the cases has been a chronic hyperplastic endolymphangitis; a fact which, combined with so complete an endothelial lining to the cysts, leads to the inevitable conclusion that these gas-containing spaces are formed in lymphatics rather than in clefts in the connective tissue.

In the type of pneumatosis, in reality an emphysema, represented by my second case, the cysts had no differentiated lining, and the smaller spaces were partly filled with a homogeneous exudate containing polymorphs, large numbers of which were also in the septa between the lacunæ (***Fig.* 375**).

Bacteriology.—Bacteria have rarely been seen or cultivated in typical examples of cystic pneumatosis. Positive findings in considerable variety have usually been obtained from cadavera, but cultures from fresh specimens have nearly always proved negative. The absence of small-celled infiltration alluded to above is also strong proof of the non-existence of bacteria. Though cultures were not taken from my specimens, examination of a series of specially-stained sections by Professor Shattock failed to reveal any micro-organisms either in the walls of the cysts or in the tissue around. In the second case the histological picture (*Fig.* 375) of an acute infective process led him to ascribe the emphysema to an infection with a gas-producing bacillus. In the few cases in which a careful bacterial investigation of fresh tissue has been made, the results have been very varied. Hahn found cocci; Jaeger isolated an organism of the colon group which he named the *B. coli lymphaticum aerogenes*; Schnyder and Schonberg grew a similar organism; Mirva found a gas-forming bacillus which grew well on sugar, but animal inoculation was negative; Norwicki considered that the colon bacillus he isolated was due to contamination; Dupraz found a colon bacillus and a Gram-negative coccus, which when mixed with lactic acid and sprayed into the vagina of dogs produced gas cysts; Shennan and Wilkie obtained a pure culture of *B. coli communis*, and Steindl isolated a Gram-positive bacillus.

The different histological appearances mentioned above, combined with the occasional isolation of a gas-forming bacillus from the material collected at the time of operation, strongly suggest the existence of two distinct varieties of cystic pneumatosis, each with a different pathogenesis. If this view be accepted, it explains many of the difficulties which writers have experienced in accounting for the origin and cause of the cysts.

Composition of the Gas.—The gas has been analysed on several occasions, but unfortunately the results have not always coincided, probably owing to the difficulty of obtaining a volume large enough for accurate calculation, and to the rapidity with which diffusion takes place through the thin cyst wall. That diffusion has an important bearing on the results of analysis was proved experimentally by Jaeger, who found that the interchange of gas in a tied coil of intestine and the air was complete in three hours.

On the whole, the composition of the cystic gas has been found to resemble closely that of atmospheric air consisting of O 10 to 16 per cent, N 84 to 90 per cent, and CO_2 0·3 per cent (Krummacher).

Composition of Gas.

	O	H	N	CO_2
	Per cent	Per cent	Per cent	Per cent
Cystic Gas (Krummacher) ..	10–16		84–90	0·3
,, ,, (Urban) ..	15·4	0·6	80	4
,, ,, (Jaeger) ..	5	73	6·1	15
Intestinal Gas (Ellenberger)	0·5	14	45	40

Jaeger arrived at a different result, viz., O 5·6 per cent, N 6·1 per cent, CO_2 15 per cent, and H 73·3 per cent; and concluded on the basis of his

experiment with the coil of intestine that earlier analyses were incorrect; but even his gas differs greatly from intestinal gas, the composition of which, as given by Ellenberger, is O 0·5 per cent, N 45 per cent, CO_2 40 per cent, H 14 per cent. Therefore in his case the gas in the cysts certainly did not emanate from the intestine.

The most reliable analysis is recorded by Urban, who obtained the gas by puncture of the abdominal cavity in a remarkable case. His patient, a boy, age 13, with a history of peritonitis at 5½, had suffered from colic, vomiting, and distention for three years, which was diagnosed as tuberculous peritonitis. At the operation, instead of tubercle, an extensive cystic pneumatosis of the small intestine, cæcum, and ascending colon was found. The cysts varied in size from a pea to a nut. Nothing was done, and the abdomen was closed. Seven weeks later, on re-opening the abdomen for excessive distention, a large quantity of odourless gas escaped, and the only cysts to be found were on a segment of ileum 50 cm. long. The others had disappeared, and their sites were occupied by small gravel-like nodules, the remains of collapsed cysts. The affected segment of ileum was short-circuited. On two occasions, one month and two months after this operation, the abdomen became greatly distended and was tapped, ¾ litre of gas being evacuated on each occasion, which was presumed to have escaped from a ruptured cyst. After this, recovery was rapid and uneventful. The gas obtained at the tappings was collected and analysed immediately by a chemist, who found it contained O 15·4 per cent, N 80 per cent, CO_2 4 per cent, and a small quantity of H.

Etiology.—The various theories which have been advanced to explain the etiology are :—

1. *The Neoplastic Theory.*

Bang considered that the cysts were formed by central degeneration of a new growth, and that the gas was secreted from the blood as in the swim-bladder of fish. Mair thought that the cysts arose in a true neoplasm, and credited the giant cells in their walls with the power of secreting gas. He also considered them analogous to the swim-bladder of fish. Finney, supported by Welch, inclines to the view that the condition is due to a distinct variety of tumour whose cells have the power of secreting gas. Kouskow, in advocating the neoplastic theory, regards the giant cells as specific formers of gas. Very few facts are required to refute this theory. In the first place, the cysts tend to disappear spontaneously, leaving in many cases a typical cicatrix, as has been proved at subsequent operations in several cases. Secondly, no analogous gas-containing tumour has yet been described in any other part of the body. Thirdly, gas cysts in connection with carcinoma (of the pylorus) have only been reported in two cases; and lastly, the microscopic appearances do not bear the least resemblance to those of a neoplasm.

2. *Bacterial Theory.*

Many writers believe that bacteria are the cause of the tissue changes and the gas. Their names and the organisms they have found have been enumerated in a preceding paragraph. It is quite natural to attribute the process to gas-forming organisms, and this accounts for the variety that have been suspected. Dupraz and others considered that bacteria gained access to the lymphatics through abrasions in the mucous membrane, and there formed

emboli which led to dilatation of the ducts. Continued growth of the organism was followed by gas-formation and conversion of the duct into a gas-containing cyst. Many of the earlier writers (Eisenlohr, Hahn, Winands, Jaboulay, Jaeger, and others) were strong advocates of the bacterial theory, and quite recently Steindl and Matronala have revived it. The latter suggests that a toxic process leads to obliteration of the lymphatics where fermentation of lymph by some 'rare germ' leads to the formation of gas cysts.

There are many facts which are opposed to the bacterial theory in the majority of cases, such as the absence of all signs of inflammation in the cysts and in the tissues surrounding them, the absence of lymph on the surface of the bowel and of adhesions to adjacent coils, the absence of profound toxic symptoms which would be inevitable considering the length of the intestine often involved, and above all the failure to discover a specific organism. Joest, in comparing intestinal emphysema of swine with cystic pneumatosis of man, points out that the mere presence of bacteria in the intestinal lymphatics does not necessarily imply that they are the cause of the gas. For this to take place two factors are necessary: (*a*) the organism must be capable of fermenting carbohydrates, and (*b*) there must be an excess of carbohydrates in the lymphatics. It might well be argued that as an organism of the colon group is the one most likely to be found in the intestinal lymphatics, Joest's postulates are in favour of the bacterial theory, were it not for the fact that von Mering has shown that under normal conditions carbohydrates are absorbed by the blood-vessels and not by the lymphatics. Finally, Plenge, in refuting the bacterial theory, points out that as the cystic gas generally contains 16 to 20 per cent of oxygen, the microbe must be an oxygen-former, a property which is not possessed by well-known types of gas-producing organisms. He emphasizes the fact that the usual gaseous products of bacterial action on the tissues are carbon dioxide, nitrogen, hydrogen, sulphuretted hydrogen, and marsh gas, but never oxygen, and considers, therefore, that the presence of oxygen is strong evidence against this theory.

3. *Mechanical Theory.*

Although there are many facts which are difficult to explain, the majority of investigators now attribute cystic pneumatosis to mechanical causes. They agree in supposing that air is forced under high pressure into the wall of the intestine through an abrasion in the mucous membrane, whence it enters the lymphatic network and is driven along the bowel both by the *vis a tergo* of constant pressure and by intestinal peristalsis. Cyst-formation is due to an obliterating endolymphangitis from irritation set up by the gas, and is seen at its best in the loose subserous and submucous connective tissue. The giant cells in the wall of the cysts are also due to irritation.

The association of cystic pneumatosis with a gastric or duodenal ulcer in quite 50 per cent of recorded cases, and with an obstructive lesion in some part of the gastro-intestinal tract in over 70 per cent, is greatly in favour of a mechanical cause, especially when it is remembered how rapidly an extensive subcutaneous emphysema may follow a comparatively minute injury in other parts of the body.

The conditions in the intestinal tract are similar, for, together with an established atrium in the form of an ulcer, the majority of patients give a

characteristic history of frequent vomiting, troublesome flatulence, and constipation, all of which give rise to an increase of intra-abdominal pressure quite sufficient to force gas through an abrasion. The opponents of this theory maintain that, as the gas has the composition of atmospheric air and not of intestinal gas, it is difficult to reconcile a mechanical cause with those cases in which a demonstrable lesion of the stomach and duodenum has not been found, and also that patients with gastric and duodenal ulcer are operated on by the thousand, yet cystic pneumatosis is very rare. This is a sound argument and has several points in its favour; but may it not be that aerophagy and gastric lavage account for the few cases of cystic pneumatosis amongst the many of gastric and duodenal ulcer, and also for the composition of the gas? Aerophagy with subsequent distention of the stomach is well known in hysteria, and veterinary surgeons are familiar with it in animals; while gastric lavage, as in my first case where it was performed daily for six years, permits the ingress of atmospheric air immediately the tube reaches the stomach, and allows a considerable volume to remain after its removal.

Symptoms and Clinical Signs.—An extraordinary feature of the condition (it can hardly be called a disease) is the conspicuous absence of symptoms referable to it. That a lesion which is frequently so extensive should not cause a definite train of symptoms is indeed remarkable. Any special features which might point to its existence are masked by the symptoms of gastro-intestinal ulcer or stenosis. In the absence of a demonstrable lesion, as in Urban's case, vomiting, colic, and distention appear to be the only distinctive symptoms. In those cases in which the lumen of the intestine is narrowed by a large collection of submucous cysts, the symptoms are those of obstruction, as in Woltmann, Neugebauer, and Wassiljew's cases; or of intussusception as in Bartsch's and one of my cases. Occasionally, as in my second case and also in those of Philip, Bubis and Swanbeck, and Twyman, an elongated swelling or a mass can be distinguished, and on one occasion von Hacker felt distinct crepitation on palpating the abdomen. In two cases (Hey, Tuffier) a radiogram has shown an abnormal transparency which was subseqently found to correspond with the location of the cysts, but, as might be expected, X rays can seldom be of much assistance in these cases. Weil classifies the lesions according to their symptoms and clinical signs in the following varieties:—

1. *Pseudo-appendicular*, in which the main features are those of a chronic or subacute appendicitis combined with a tender mass or elongated tumour in the right iliac fossa.

2. *Peritoneal*, characterized by abdominal distention, colic, vomiting, and ascites, and simulating either tuberculous or perforative peritonitis.

3. *Obstructive*, where the symptoms are those of an acute or chronic obstruction, due either to paralytic ileus from extensive cyst-formation, or to definite narrowing of the lumen of the bowel by a mass of submucous cysts.

4. *Tumorous*, in which a definite tumour is palpable.

Though this classification is somewhat artificial, it applies to some of those recorded cases in which the signs and symptoms were sufficiently distinct to puzzle or mislead the clinician.

Treatment.—The cysts and the portion of intestine affected are best left alone unless they are causing obstruction by pressure, adhesions, or projection

into the lumen of the bowel. In the great majority of cases, after treatment of the co-existing disease the cysts disappear spontaneously. This has been proved on several occasions by Kadjian, Mori, Urban, Faltin, and others, at a second operation, when the cysts were found to have disappeared either wholly or in part. The cysts should never be crushed or punctured owing to the danger of subsequent perforation of the weakened intestinal wall. Entero-anastomosis should rarely be necessary, and resection is only required where a mass of submucous cysts are causing obstruction, or in the type of bacterial emphysema illustrated by my second case.

Duration and Prognosis.—Except in cases of bacterial emphysema, the duration of the condition, from its commencement to the time of its discovery at an operation, is variable and uncertain, for any symptoms it may give rise to are masked by those of the primary disease. Also, unless the upper coils of intestine are carefully examined for the scars of collapsed cysts, a collection on a lower coil might be considered a recent formation, whereas in reality the gas in it has only been slowly driven along the intestinal wall, passing the fibrous remains of collapsed cysts and obliterated lymphatics on the way.

The prognosis is uniformly good, provided the primary disease is treated efficiently.

The diverse and often contradictory results of bacteriological investigations and of gas analyses have led to much confusion. In the writer's opinion there are two definite groups of intestinal pneumatosis: (1) the cystic and mechanical variety—the one most often seen and described—and (2) the less frequent form due to infection by gas-producing organisms. The two cases reported at the beginning of this paper fall naturally into these groups.

In *Case* 1, where there was definite pyloric stenosis and where the cysts were more or less evenly distributed over a great length of intestine, there was not the least sign either clinically or microscopically of a bacterial infection. The patient had no pyrexia, toxic symptoms, or symptoms referable to the cysts which might have been expected in so extensive a lesion had gas-producing organisms been the exciting cause. Moreover, sections specially prepared and stained from material removed at the operation, and placed immediately in a hardening solution, showed a complete absence of bacteria or inflammatory changes. The lesions in this case, which is similar to the majority of cases described by other writers, are best explained by the mechanical theory.

Case 2, on the other hand, differed clinically, macroscopically, and microscopically. A definite tender tumour was palpable through the abdominal wall; the disease was limited to the large intestine, where gas-producing organisms flourish; the walls of the bowel were thickened and inflamed; and on section the emphysema was found to be limited to the submucosa and similar in many respects to the subacute form of emphysematous cellulitis complicating a wound infected with *B. coli* or an attenuated *B. aerogenes*. Microscopically the spaces had no endothelial lining, and both they and the tissue between them contained large numbers of polymorphs, a typical picture of a somewhat acute infective process caused by a gas-forming micro-organism.

TABULATED LIST OF 85 RECORDED CASES.

No.	Author	Year	Co-existing Lesion and Remarks	Discovered at Operation or Post Mortem
1	Bang	1876	Death from volvulus of sigmoid ..	Post mortem
2	Marchiafava ..	1882	Pyloric stenosis	,, ,,
3	Eisenlohr	1888	Death from heart disease	,, ,,
4	Camargo, de ..	1891	Death from pulmonary tuberculosis	,, ,,
5	Kouskow	1891	Gastric ulcer	,, ,,
6	Winands	1895	Chronic gastric ulcer	,, ,,
7	Kolli	1895	Gastric ulcer	,, ,,
8	Orlandi	1896	Death from intestinal obstruction ..	,, ,,
9 10 11 12	Dupraz	1897	Intestinal tuberculosis in one case Pernicious anæmia in another	,, ,,
13	Hahn	1899	Dilated stomach and ascending colon. ? Gastric ulcer	Operation
14	Korte	1899	Pyloric ulcer and stenosis	Post mortem
15	Wickerhausen ..	1900	,, ,, ,, ,, ...	Operation
16	Jaboulay and Tolot	1901	,, ,, ,, ,, ...	,,
17	Vallas and Pinatelle	1901	None	,,
18	Miwa	1901	Gastric ulcer and stenosis	Post mortem
19	Verebely	1901	Intestinal tuberculosis	,, ,,
20	Kadjian	1902	Tuberculous peritonitis	Operation
21	Thorburn	1902	Pyloric ulcer and stenosis	,,
22	Nigrisoli	1902	,, ,, ,, ,, ...	,,
23	Von Hacker and Von Hibler ..	1903	Perforated gastric ulcer	,,
24	Ciechanowski ..	1904	Gastric ulcer with stenosis	Post mortem
25	Stori	1904	Pyloric ulcer and stenosis	Operation
26	,, ...	1904	Pyloric stenosis	,,
27	Viscontini ..	1904	,, ,, ...	,,
28 29 30	Lubarsch	1906	No clinical details	Post mortem
31	Mori..	1907	Pyloric stenosis	Operation

TABULATED LIST OF 85 RECORDED CASES—*continued.*

No.	Author	Year	Co-existing Lesion and Remarks	Discovered at Operation or Post Mortem
32	Mair..	1907	Pyloric stenosis	Operation
33	Mitchell	1907	,, ,, ...	,,
34	Gröndahl	1908	Duodenal ulcer and stenosis	Post mortem
35	Finney	1908	Carcinoma of pylorus	Operation
36	Herman	1908	?	Post mortem
37	Nowicki	1909	Gastro-enteritis	,, ,,
38	,, ...	1909	Heart disease	,, ,,
39	,, ...	1909	Pulmonary tuberculosis	,, ,,
40	Woltman and Wasiljew	1909	No coexisting lesion discovered; previous operation for appendicitis	Operation
41	Jamanouchi ..	1909	Pyloric ulcer and stenosis	,,
42	Shennan and Wilkie	1909	Pyloric stenosis	,,
43	Wiesinger ..	1910	Chronic intestinal obstruction by adhesions	,,
44	Urban	1910	No coexisting lesion found	,,
45	Arzt	1910	Pyloric stenosis	,,
46	Simmonds	1910	Gastric ulcer	,,
47	Martini	1910	Pyloric stenosis..	,,
48	Neudörfer	1910	Pyloric ulcer	,,
49	Ciechanowski ..	1911	No details	?
50	,, ..	1911	,, ,, ...	?
51	Miyake	1911	Chronic appendicitis	Operation
52	Philip	1911	No coexisting lesion discovered ..	,,
53	Bindi	1912	,, ,, ,, ,, ..	Post mortem
54	Cilli	1912	?	Operation
55	Uchino	1912	?	,,
56	Turnure	1913	Perforated gastric ulcer	,,
57	Lejars	1913	Pyloric stenosis	,,
58	Barjon and Duparquier ..	1913	Gastric and pyloric ulcers	,,
59	Mauclaire	1914	Pyloric stenosis	,,

TABULATED LIST OF 85 RECORDED CASES—*continued.*

No.	Author	Year	Coexisting Lesion and Remarks	Discovered at Operation or Post Mortem
60	Neugebauer ..	1914	Tuberculosis of cæcum	Operation
61	Demmer	1914	Pyloric stenosis	,,
62	Warstat	1917	Pyloric ulcer and stenosis	Post mortem
63	Schnyder	1917	Death from uræmia	,, ,,
64	,, ...	1917	Death from diphtheria and myocarditis	,, ,,
65	Moreau	1917	?	?
66	Kuder	1918	Carcinoma of pylorus	Operation
67	Mathieu-Pierre Weil	1919	Dilated stomach. No pathological lesion	Operation and post mortem
68	Tuffier	1919	Pyloric stenosis	Operation
69	Letulle	1919	Intestinal tuberculosis	Post mortem
70	Cristol and Porte	1919	No coexisting lesion	Operation
71	Lafoucade	1919	Pyloric ulcer and stenosis	,,
72	Nitch and Shattock	1919	Pyloric stenosis	,,
73	,, ,, ,,	1919	No coexisting lesion	,,
74	Twyman ..	1919	? Appendicitis	,,
75	Hey	1920	Pyloric ulcer and stenosis	,,
76	Alessandri ..	1920	Pyloric stenosis	,,
77	Sloan	1920	,, ,, ...	,,
78	Torraca	1920	?	?
79	Plenge	1921	Pyloric stenosis	Operation
80	,, ...	1921	,, ,, ...	,,
81	Steindl	1921	No coexisting lesion discovered ..	,,
82	Wanach	1922	Pyloric ulcer and stenosis	,,
83	Bubis and Swanbeck	1922	Ulcer at base of appendix	,,
84	Schulte	1922	Duodenal ulcer	,,
85	Matronala	1922	Pyloric stenosis	,,

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OSTEOGENESIS IMPERFECTA.

By R. LAWFORD KNAGGS, London.

(*Being the Hunterian Lecture delivered at the Royal College of Surgeons of England on Feb.* 13, 1924.)

Osteogenesis imperfecta is the name given to a disease which is characterized by a congenital defect in the evolution of the osteoblast, and recognized clinically by defective ossification of the cranium and a multiplicity of fractures resulting from trivial causes.

Cases, now recognized as instances of this affection, are scattered throughout literature under such titles as fœtal rickets, idiopathic fragilitas ossium, and osteopsathyrosis; whilst Porak and Durante have suggested the name 'periosteal dystrophy' to distinguish it from another congenital bone affection, chondro-dystrophy fœtalis or achondroplasia. At first it was believed to be incompatible with life, and that the subject of it was still-born or died within a few minutes of its birth. Then it became evident that some infants survived for varying lengths of time, whilst others, who had shown some signs of the intra-uterine affection at birth, gradually developed a tolerably healthy childhood, with a liability to fractures which slowly diminished. Thus a link was established with those cases in which the child was born apparently healthy, and an abnormal predisposition to fractures discovered only when it began to get about. Now the belief grows that these different sets of cases have a similar pathology.

THE CLINICAL ASPECT.

A comprehensive picture of the disease may be formed from a few typical cases illustrating its four clinical varieties. These occur: (1) *In the fœtus*; (2) *In the infant*; (3) *In the child or adolescent*; (4) *In middle or late life.*

1. THE FŒTAL FORM.

Most cases are still-born or survive only for a very short time. They usually show large numbers of fractures of the ribs and other long bones, and the lower extremities, more particularly, are apt to be deformed and shortened in consequence. Some of these fractures are united.

The ossification of the skull is usually very incomplete. In extreme cases the cranial vault is little more than a membranous bag with a few small, thin, isolated plates of bone corresponding to the normal ossific centres; whilst the base is likely to be shorter than usual antero-posteriorly, thus favouring a cretinoid appearance of the face. In others, scattered osseous plates and patches help to some extent to fill in the spaces which separate the immature flat bones of the vault. These bone islands are the forerunners of the numerous

Wormian bones which are such a conspicuous feature of the completely ossified skull of osteogenesis imperfecta. In the light of this inadequate protective covering of the brain, it is easy to understand what must be the effect of the powerful uterine contractions during labour. No wonder such cases are still-born. As a good example of this group, Dr. Herbert R. Spencer's case may be cited.

Case 1 (*Figs.* 380, 381).—The specimen is in University College Hospital Museum (No. 632, Bone 61A), and is described in the catalogue as follows :—

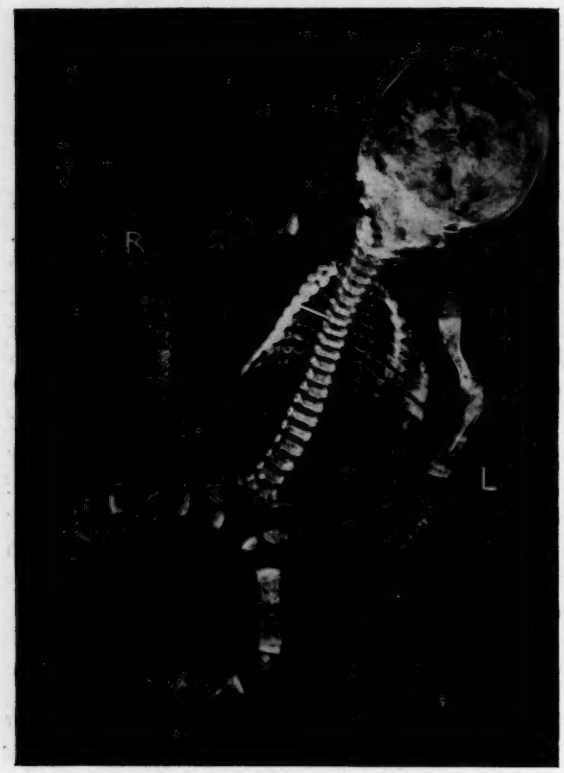

FIG. 380.—*Case* 1 (Dr. H. R. Spencer's). The curious appearance of the skull is due probably to the interior of the membranous envelope being filled with wool. The thin calcareous plates are well shown.
(*Univ. Coll. Hosp. X-ray Department.*)

" The skeleton of a rickety fœtus. The ossification of all the flat bones of the cranium is defective, irregular plates of very thin bone being widely separated by intervals which are in parts entirely membranous, and in others are undergoing ossification in irregular striæ. The bone in many parts is so thin as to give the finger a sensation like the crackling of parchment, the thinness being such that the shape of the skull could only be maintained by filling the cavity with wool. The *lower jaw* is fractured on each side in front of the masseter. The *vertebral column* presents a normal appearance. The *wall of the thorax* presents on each side a vertical groove outside the junction of the ribs with the cartilages. The *ribs* are sharply bent at their angles, especially on the right side, and there are several swellings of the bones in this situation which appear to indicate fractures." The clavicles and scapulæ are not preserved. " In the *right upper extremity* the *humerus* is curved outwards as the result of a healed fracture in the middle of the shaft. There is a recent fracture close to the lower extremity. The upper extremity of the shaft is considerably thickened. The *radius* and *ulna* present an enlargement in the middle of their shafts following the repair of a fracture ; each bone has also been recently fractured in the upper and lower part of its shaft, and the lower end of the shaft of each is thickened. In the *left upper extremity* the *humerus* is curved outwards even more markedly than the right, and presents two ununited fractures below its middle. The *ulna* is fractured about its middle, and the *radius* at a lower level. The *5th metacarpal bone* is fractured at its lower end.

" The *pelvis* is flattened from before back, and its cavity is contracted. The inlet of the true pelvis has the shape of a triangle with the corners rounded. The *left ilium* is fractured transversely a little below the crest.

" In the *right lower extremity* the femur is bent outwards and the leg bones prominently forwards, so that the thigh and leg bones display a semicircular

outline. The *femur* presents two repaired fractures, one at, the other above, the middle, and an ununited fracture midway between the middle of the shaft and the lower epiphysis. The *leg bones* are the seat of unrepaired fractures in the middle of their length, and in the fibula also at its upper extremity. The *foot* bones are normal. The general appearance of the bones of the *left lower extremity* is similar to that of the right. The femur is fractured in the middle of its length, and the *leg bones* in two places at and below their middle. In both limbs the ends of the long bones are considerably enlarged, and, as in the upper limbs, the growth in the length of the long bones is deficient."

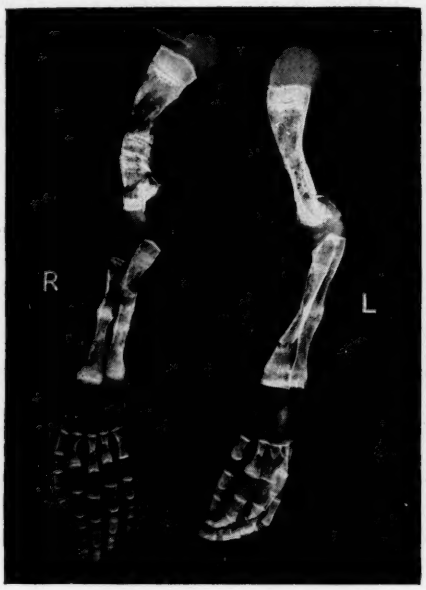

FIG. 381.—*Case* 1. Both upper extremities, showing sharp epiphyseal lines, multiple fractures, united and ununited, and rarefaction of cancellous tissue except where callus has formed. The shortness of the diaphyses is very evident.

Through the kindness of the Curator of the Museum (Dr. Lawrence), and of Dr. Salmond, of the X-ray department of University College Hospital, I am able to show radiographs of the specimen; I have also had the opportunity of studying its histology. The radiographs show the clean, sharply-defined junctions of the epiphyseal cartilages with the

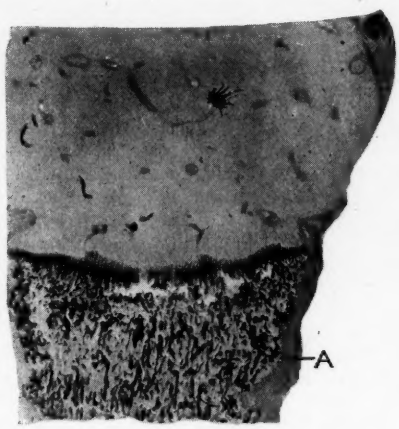

FIG. 382.—*Case* 1. Section of upper end of femur (× 3). No artificial decalcification. It shows the same characters as the photomicrographs of *Case* 3, but atrophy of the trabeculæ is not so marked. *Fig.* 383 is taken from the point A. (I am indebted to Dr. G. H. Rodman for all the photomicrographs.)

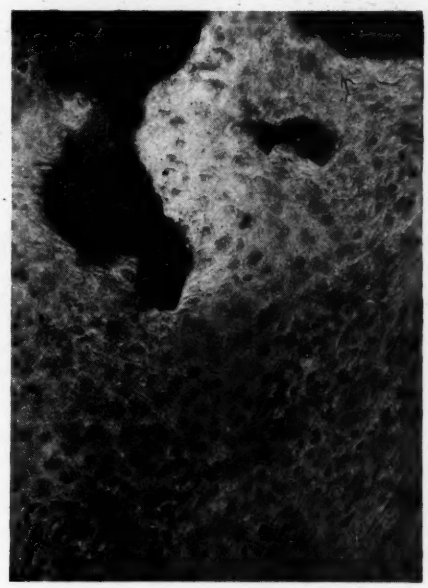

FIG. 383.—*Case* 1. Highly magnified (× 175) portion of section in *Fig.* 382. Cartilage-cells are seen originating from the periosteum and passing between the trabeculæ which are developing by metaplasia. The periosteum is in the right-hand lower corner.

diaphyses, and, together with the microscopical findings (*Figs.* 382, 383), completely dispose of any question of rickets.

2. THE INFANTILE VARIETY.

This is the continuation of the fœtal disease in those cases which survive their birth and drag out a precarious existence for a few months or a year or two. It represents a less severe form of the disease than that present in the purely fœtal group. These cases at birth show marked signs of the defective intra-uterine ossification. Their fragile limbs continue to break almost with a touch, and, though the development of the cranial vault is far in advance of the membranous bag type, it is still very imperfect. Such cases may be seen occasionally in children's hospitals.*

Case 2.—Dr. F. J. Poynton[1] describes one that had been in hospital for two years, and adds that he knew of no cases recorded in the literature in which more precise treatment had been undertaken. Yet the final condition was deplorable. All the long bones were at one time or another broken, and eventually, when the boy was lifted with the hands put round the chest, his ribs could be felt to snap.

Case 3.—Another case, whose histology is illustrated by several photomicrographs (*Figs.* 389–94, 397–9) is that of a female child who died when 20 months old. She was born with one leg broken and the other limbs bent. When 9 months old she was an in-patient at Great Ormond Street Hospital under Mr. Tyrrell Gray.

The notes state: The head was markedly flattened from before back, the ribs were slender, and the upper and lower limbs were much deformed from partial fractures. The heart, lungs, and abdomen presented no signs of disease, and the tongue was the seat of superficial glossitis. The X rays showed a marked absence of compact tissue in the different bones. For ten months before death she had been subject to fits, which continued till she died the day after her readmission to the hospital.

All the long bones of the skeleton (R.C.S. Museum, A715), "including the metacarpals and metatarsals, exhibit different degrees of imperfect formation, being abnormally slender and bent. The humeri, femora, and bones of the leg are, moreover, the seat of fractures, which in the case of the femora are multiple and fairly symmetrical. The various segments of the pelvic bones are unnaturally thin and hypoplasic, as are also the scapulæ. In the ilia and bodies of the scapulæ there is

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* Cases of fœtal and infantile osteogenesis imperfecta have frequently, in the past, been called 'fœtal rickets'. There is no sufficient reason why it should not be possible for rickets to occur in the fœtus. There is, however, some scepticism about it. Dr. Poynton in his lecture refers to a specimen shown by Dr. Dawe at the Pathological Society. The specimen was a card specimen, and no account of it is to be found in the *Transactions*; but the microscope sections exhibited were considered to show the characteristic rickety changes, and were taken from a still-born child whose "ribs showed typical beading at the costochondral junctions, and the bones of the limbs similar disturbance of growth at the ends of the diaphyses". (Private communications from Dr. Dawe and Professor Shattock.)

A specimen in St. Thomas's Hospital Museum (No. 364A) illustrates the difficulty of making a certain diagnosis when an infant born with evident signs of some congenital bone affection survives long enough for rickets of a post-natal origin to supervene. The catalogue description is as follows: "The left lower limb of an infant showing characteristic marks of rickets. In addition to the epiphyseal and other changes in the long bones, the hip bone is considerably increased in thickness. The disease was congenital. The skeleton in general was affected—the various long bones are shown in the specimen, whilst the flat bones were abnormally thickened. The child was one of twins, and was born with deformities of the limbs. The long bones during life could be bent like indiarubber. Death occurred when the child was 16 months of age from marasmus and broncho-pneumonia. The other twin, a boy, was, like the girl, very backward and unable to walk. He exhibited the same flexibility and curvature of the bones but to a less degree. Both children had been brought up on cow's milk and 'Robinson's food'. The parents were healthy and the mother knew of nothing unhealthy in her diet during pregnancy."

An angular deformity in the femur of the specimen is obviously the result of a healed fracture.

an actual circular deficiency at the spot in which each is naturally thinnest. The ill-developed condition of the ribs has led to incomplete fractures in several situations, as evidenced by local thickenings. The bones of the face participate in the same hypoplasia. The skull is hydrocephalic ".

In the calvarium (Aa 715), " the bones are extremely thin, especially the two parietals, which are translucent over the summits of the convolutions. The anterior fontanelle is widely open. In consistence the osseous tissue is quite as firm as normal ".

FIG. 384.—*Case* 4 (Mr. Tyrrell Gray's). Skiagram of the right lower extremity at the age of 3 years. The architecture of the bones has not been brought out owing to the tube used being ' soft '.

FIG. 385. —The same extremity at the age of 8 years. Here a ' hard ' tube has brought out the bone architecture at the expense of the soft parts. Note the thin cortex, the rarefied cancellous tissue, the straight epiphyseal lines, and the evidence of old fractures.

The brain (3835E, R.C.S. Museum) has a remarkable circular outline when viewed from above. Its large size and slightly broadened convolutions suggested a condition of hydrocephalus, but on investigation the ventricles were found quite normal.

Of the internal glands, the thyroid, the suprarenal, the pituitary, the ovary, and the liver were examined. The thyroid only was abnormal. The cells did not line the alveoli, but occupied the interior generally in a mass. In some of these masses there was a suggestion of a collapsed cavity; in others the cells were scattered generally throughout the alveolus in the colloid substance.

Through the kindness of Mr. Tyrrell Gray, and with the help of Mr. George A. Mason, I am able to refer to another case of very considerable interest :—

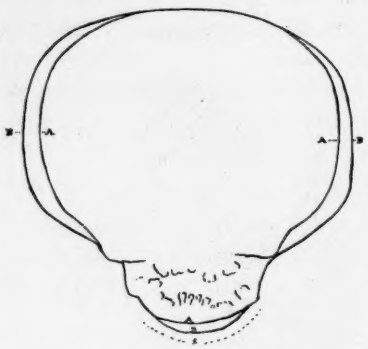


FIG. 386.—*Case* 4. Outlines of the cranium at age of 3 (A) and 8 years (B) superimposed.

Case 4 (*Figs.* 384, 385).—A. P., a boy, age 8 years, was first brought to the Children's Hospital, Great Ormond Street, when 3 weeks old, and frequently attended afterwards for various fractures. He measured, when laid at full length, 27½ in., and the height of a normal boy of the same age is 47·05 in. (British Association Anthropometric Committee Report, Table xvi). A proportion of this deficiency in height was explained by the curving of the spine and by the bending and deformity of the lower limbs, which was very similar to that seen in *Case* 1 (*Fig.* 380), but a considerable part of it was clearly a consequence of diminished growth. The skull, like that of *Case* 3, was hydrocephalic in appearance. The forehead was very prominent and broad, and the temporal regions protruded remarkably. Whilst the bitemporal diameter was greatly increased, the anteroposterior diameter seemed shorter than normal owing to the flattening of the back of the head. A face, small for the child's age, appeared overweighted with a bulging and greatly expanded cranium, which, however, was completely ossified. The horizontal circumference was 22½ in., that of a normal adult skull being 21 in. Skiagrams taken when the child was 3 years old were able to be compared with those taken when it was 8. Superimposed outline tracings of the front views of the head show the increase in size during the five years to be due to lateral expansion of the vault (*Fig.* 386).

The recent skiagrams of the limbs demonstrate well the very delicate architecture of the osseous tissue and the thinness, or in parts the absence, of cortex. The child was very intelligent, looking as it sat up in bed not unlike a child 2 years old, but giving the impression of a mentality much in advance of that age. It had never had any fits or nerve symptoms, and after the investigation of the brain in *Case* 3 there can be no doubt that the shape of the cranium was not dependent on hydrocephalus.

FIG. 387.—(*No.* 3879, *R.C.S. Museum.*) Skeleton of a boy, age 12 years, showing osteogenesis imperfecta and hydrocephalus.

But hydrocephalus may undoubtedly be an associated condition. An example of it is seen in the skeleton of a boy, age 12 (from Professor Himley's Museum) (*Fig.* 387), in whom the left humerus and ulna, the right radius, and both femora and the left tibia appear to have been at distant periods fractured and repaired with various degrees of distortion. The skull is of globular form and nearly symmetrical. It measures in its transverse circumference 31 in.; from one auditory meatus to the other over the vertex 27 in.; and from the nasal spine to the foramen magnum 26 in. (R.C.S. Museum, No. 3879.)[2]

3. THE DISEASE IN CHILDHOOD AND ADOLESCENCE.

(Osteogenesis Imperfecta Tarda—so-called Idiopathic Fragilitas Ossium.)

The third category is very different from the other two, and the cases which belong to it have commonly been described under the heading of 'idiopathic fragilitas ossium'.

In the bulk of them the infant is apparently healthy at birth, and has a perfectly normal childhood except for the fact that fractures of the long bones occur at more or less frequent intervals from very slight causes. There is often some evidence of defective cranial ossification in the presence of soft places on the vault, but in many, beyond a late closure of the anterior fontanelle, signs of cranial abnormality may be almost absent on clinical examination. There are wide variations in the number of fractures in different cases. In many it is under 10, not infrequently between 10 and 50, and in a few cases it may reach well over 100.

In less aggravated conditions the liability to fracture seems gradually to wear itself out as maturity is reached. Looser pointed out that these cases of multiple fractures presented the same pathological peculiarities as the fœtal and infantile cases of osteogenesis imperfecta, and suggested for them the designation of 'osteogenesis imperfecta tarda'.

A very strong familial tendency is often present in the post-natal disease. Sometimes two or three children in a family will suffer; occasionally a whole family, and more rarely several generations, will show the taint. These hereditary instances sometimes present a very interesting grey-blue coloration of the sclerotic, a complication which will be considered later. The intensity of the disease may vary considerably, as the following instances show.

The first case represents a transition between the infantile and the adolescent types:—

Case 5.—Fowler[3] has described the case of a boy who began with a fracture on the fourth day after birth, and had seven up to the age of 3, when he was lost sight of. In addition to patent cranial sutures, the occiput was almost entirely undeveloped. The sutures were in process of closure at the fourteenth week, but he was a year old before the back of the skull was properly ossified. He was small for his age at 3.

Axmann's case[4] is an example of the ordinary adolescent form:—

Case 6.—This case is mentioned by Crozier Griffith[5] in these terms: "The writer gives his own family history. He and two brothers were of rather delicate build. He had a fracture of the leg in his third year; one brother had 9 fractures from the age of two to that of nineteen years, 4 of them occurring before six years of age. The other brother had 9 fractures from the age of two to that of nineteen years, 4 of them before he was nine years old. These 14 fractures" (*sic*) "occurred without the action of any noteworthy force. All healed in four or five weeks. The fragility decreased with growth and disappeared at maturity."

O. Schmidt's fourth case is an instance of an aggravated form of this variety. It is of more than ordinary interest, because it formed the text for Looser's article on osteogenesis imperfecta tarda, in which a very full histological report on the different bones is given.[6]

Case 7.—"A youth, 17 years old, was descended from healthy parents. Nine brothers and sisters died at an early age in convulsions. A sister aged 14 was healthy, and a brother aged 6 years suffered from fragility of the bones."

"The labour was normal, and at birth the boy was normal and strong. He developed well in the first month, but later his health suffered owing to convulsions and much diarrhœa. He learnt to walk at the normal age, and the first fracture occurred when he was 1½ years old. Very numerous fractures followed at longer or shorter intervals, most from quite insignificant causes. Up to his 17th year he had 43 fractures in all, 40 of the legs, 2 of the upper arm, and 1 of the right clavicle. He had been in hospital with fractures of the scapulæ, upper part of the thighs, lower jaw (from chewing), forearms, upper arms, and probably of the bodies and processes of the vertebræ, besides many infractions. In the case of slight fractures they soon united. Fractures were observed to consolidate in very short periods. The great deformity due to union with much displacement made walking impossible from the 12th year. When admitted to a private home his internal organs were normal. He had kypho-scoliosis, his upper extremities were not much changed, but the lower ones were bent into corkscrew shape. Both legs being useless were amputated in the lower third of the thigh. Subsequently, during a year of hygienic and dietary treatment, the bone fragility improved considerably."

FIG. 388.—*Case* 8. Skeleton of Ormerod's case presented to the R.C.S. Museum by the staff of the Sussex County Hospital.

4. THE DISEASE IN MIDDLE LIFE OR OLD AGE.

Osteogenesis imperfecta in an active state is of rare occurrence in later life. In Dr. E. L. Ormerod's remarkable case there was a relapse following a satisfactory recovery from a slightly pronounced intra-uterine form of the malady. In Hektoen's case there is no history, but the presumption is that the disease had reached a quiescent state.

Case 8 (*Fig.* 388).—The skeleton in the R.C.S. Museum was given by the staff of the Sussex County Hospital, and the case was recorded by Ormerod[7] in 1859 :—

The patient, who lived to the age of 68, was the last of a family of six children, and the only one to reach middle life. His father was of dissolute habits and good physique, and died of diabetes at 55 ; his mother lived to 93, had some miscarriages, and some other children who died within a few days of their birth.

He was born with his arms broken. Otherwise he was a fine child, and, though rickety, improved as time wore on, until he was 30 years of age, when, in spite of his deformities and an accident four years before in which both his thighs were injured, he was 5 feet 3 or 4 inches in height, and had full use of his arms and legs.

He could walk several miles, and do a good day's work as a shoemaker without any inconvenience. He was in his prime, and at this age he married.

At the age of 40 he seemed to have lost all his bodily strength, and his bones were so brittle that they would break at the slightest blow. His marriage, and some pecuniary losses which had reduced him to poverty, may have had something to do with the change that came over him in these ten years. At one and the same time he had no fewer than seven fractures of different bones. They were attended by little pain and swelling or constitutional suffering, and united even more readily than healthy bones. It does not appear that he suffered from any pain in the bones preceding the fractures. His wife got used to his bones breaking, and as he lay in bed for the last four years of his life a fracture might often have passed unnoticed in the family circle. It was subsequent to the age of 30, when he married and poverty overtook him, that the chief changes in his skeleton—both in the gradual bending and the sudden fractures—occurred. He died worn out by the constant pain of his distortions and some ulcers on his legs, and after death, when laid at full length on his back, he measured 39½ in.

He was the only one of his brothers and sisters to be affected in this way, but a son and a daughter suffered from frequent fractures and attended the hospital for them. Two other children died soon after their birth, but were healthy-looking.

Case 9.—Hektoen[8] gives an interesting account of the findings in the case of a small, short-limbed dwarf, age 45. The skeleton—whilst showing some of the features of osteogenesis imperfecta, viz., the curving of the bones, old fractures of many ribs and the left humerus, evident deficiency of periosteal and myelogenic ossification, and a very remarkable skull—presented also certain appearances suggestive of achondroplasia in the relative shortness of the limbs and the swollen condition of the articular ends (achondroplasia hyperplastica of Kaufmann).

The feature that has led me to mention this somewhat anomalous case is the condition of the skull, which is characteristic of osteogenesis imperfecta. It is remarkable for the large number of Wormian bones in its composition, viz., 172. They were most numerous in the posterior and lateral portions of the skull, supplanting the parietals, the squamous portion of the temporal bones, and the upper half of the tabular portion of the occipital. Others occurred in the vertical and orbital portions of the frontal bone. The base of the skull, which is primarily developed in cartilage, was free from them.

These cases give a very good idea of the clinical characters of osteogenesis imperfecta.

There can be no doubt that the foundation of the mischief is laid in early intra-uterine life, and that the causal defect is present in the fœtus even in those cases in which the first signs of trouble do not appear until after birth. The less pronounced that defect, the greater is the probability that its signs will be deferred till the individual is able to get about, and is exposed to the ordinary slight traumatisms of a healthy life. Recovery is not necessarily permanent, and recurrence may take place when general conditions are unsatisfactory.

It would appear from a general perusal of the literature that the subjects of this affection are smaller than normal at birth and throughout life, and that the prognosis as to longevity is not good. The numerous fractures are largely responsible for the excessive shortening, and probably also for the thickening which is often present; but the feeble osteogenic process at the epiphyseal lines has no doubt considerable influence. In some cases the skin appears redundant and is thrown into folds, which has been explained on the ground that the growth in length of the bones has not kept pace with

the growth of the skin; whilst in a certain number of cases a cretinoid type of face is recorded.

The fractures are in the main subperiosteal, and arise from the most trivial causes. The earlier they appear, the greater, as a rule, is the liability to them. They unite readily, sometimes more quickly than in normal bones, and the callus is much more dense than the rest of the bone. Instances of non-union are not uncommon. The small amount of pain and inflammation they give rise to may be explained by the subperiosteal character of the fracture causing little or no laceration of the soft parts, and by the atrophic condition of the bone substance. Poynton noticed that slight febrile attacks and bony tenderness preceded fracture; but probably this means that partial fracture predisposed to the final complete solution of continuity. Deformity, which in the lower extremities is often very considerable, may be due to bending of the bones resulting from in-fracture of a thin brittle cortex at one portion of its circumference, and not to flexibility of a softened osseous tissue; but it is mainly caused by improperly united fractures.

The ease with which union takes place suggests that the deformity is preventable; Nathan, indeed, attributes it to the fact that, owing to the frequency and painlessness of the fractures, the patient, or those who look after him, become careless and fail to give the necessary attention.

The defective ossification of the skull is particularly noticeable in the vault, i.e., in that part of the skull developed in membrane; but the base also is affected. The bone developed from cartilage in other situations is composed of atrophic and widely separated trabeculæ of a very porous type, and it can readily be understood that pressure, acting upon similarly formed bone in the basi-sphenoid and basi-occipital, might exert some repressive influence upon the anteroposterior diameter of the base. But it is to the want of growth resulting from the feeble endochondral ossification that the relative shortness of this part of the base is usually attributed. It is this shortness which is responsible for the cretinoid facies met with in some of the fœtal cases.

In the vault, almost every degree of deficiency may be found in different cases, from a membranous sac with occasional bony spicules here and there (Stilling's case), to cases in which the fontanelles are large and the sutures still open. If the infant survives and thrives, ossification progresses and sutures and fontanelles close (*Case* 5); but occasionally a soft place in the skull may persist for years and even throughout life. The membranous areas that intervene between the immature bones are apt to become filled in by numerous Wormian bones resulting from discrete patches of ossification. Remarkable appearances are thus produced, the vault being represented by a mosaic of larger and smaller bone plates, sometimes touching one another, and sometimes united by bridges of periosteum and dura (Hektœn's, Vrolik's, Schmidt's, and Harbitz's cases). The skull of *Case* 8 is a good example of this excessive Wormian bone formation.

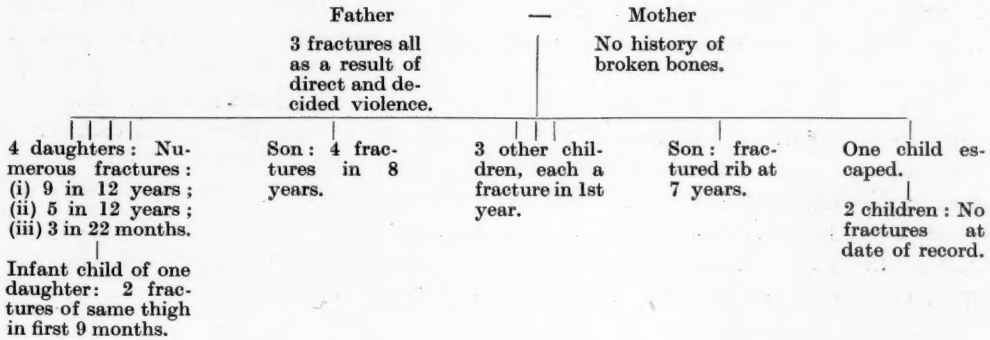
Owing to this slow and defective ossification the shape of the cranium in osteogenesis imperfecta tends to become distinctive. The bitemporal diameter is much increased, the squamous parts bulging outwards and projecting considerably above the external auditory meatuses, so that the ears are

directed downwards and outwards. This is very marked in *Case* 4, and also in *Case* 3, in which the bulging involves the occipital and also, to a less degree, the frontal regions.

The probable explanation of this deformity is the lack of support given the brain by its limp and pliable osteo-membranous envelope. It is apt to be looked upon as evidence of hydrocephalus, but that diagnosis should not be made without actual examination of the cerebral ventricles.

THE TENDENCY TO HEREDITARY TRANSMISSION.

There is abundant evidence to show that the disease may appear in more than one member of the same family, and that even several generations may suffer. Willard[9] records the following remarkable family history :—


Father
3 fractures all as a result of direct and decided violence.
—
Mother
No history of broken bones.
4 daughters: Numerous fractures: (i) 9 in 12 years; (ii) 5 in 12 years; (iii) 3 in 22 months.
Infant child of one daughter: 2 fractures of same thigh in first 9 months.
Son: 4 fractures in 8 years.
3 other children, each a fracture in 1st year.
Son: fractured rib at 7 years.
One child escaped.
2 children: No fractures at date of record.

Other instances are mentioned by Greenish[10], and still others are referred to in the next paragraph, whilst recorded cases not infrequently furnish testimony to the transmission of the idiosyncracy.

Blue Sclerotics.—A connection has recently been shown to exist between these post-natal cases of osteogenesis imperfecta and a greyish-blue colour of the sclerotic. The peculiar tint of the eyeball attracted special attention, because it was found to occur with some frequency in several members of a family, and sometimes to appear in more than one generation. The discovery of a history of several fractures in one case led to the investigation of others, and it was found that multiple fractures were quite common in individuals who presented it. The blue colour is due to the partial visibility of the pigmented choroidal tunic through the sclerotic.

Such investigations as have been made would seem to show that there is no diminution in the thickness of the sclerotic compared with the normal, and no difference in its microscopical structure. It is therefore suggested that the translucency of the outer ocular coat is due to some exceptional peculiarity of the fibrous tissue of which it is composed. In support of this idea, the disproportionate frequency of sprains in these people is advanced as corroborative evidence of some abnormality of the fibrous tissue in other parts of the body. The most comprehensive contribution to this subject is Bronson's[11]. It is based upon a careful study of two families, and from his summary of the main facts connected with them we can appreciate its relation to osteogenesis imperfecta.

1. *The First Family.*—In 4 generations there were 55 individuals, and 21 had grey-blue sclerotics. Of these 21, only one, a boy of 6 years, had had no fractures. The number of fractures in any individual was not excessive, and they required a certain amount of force to produce them. Sprains and dislocations were common. The majority of the adults were in good general health and able to do ordinary work. The mortality among the infants with blue sclerotics was greater than amongst those not so affected. The heads of those in this family who had blue sclerotics and bone fragility showed an abnormal prominence of the frontal and occipital bones. In two there was a history of patent fontanelle throughout life. Of 8 adults with blue sclerotics and fractures, 7 had varying degrees of deafness. The eighth died at the age of 23 without deafness.

2. *The Second Family.*—This includes 3 generations and 8 individuals; 7 had blue sclerotics, and 4 of these had had fractures. Two others had a tendency to sprains. All were able to lead an ordinary life except one child, who was crippled and incurred fractures too easily to be able to run about and play. In this family the head had the characteristic shape frequently seen in osteogenesis imperfecta, viz., an increase in the bitemporal diameter, so that the ears were turned outwards and downwards. There was slight downward tilting of the eyes, and an underhung lower jaw. There was no tendency, as in the first family, to deafness, nor was there any arteriosclerosis.

In both families the stature of affected individuals was below the average, with the exception of three members of the first family.

HISTOLOGY.

There is general agreement on the part of those who have had opportunities of studying the histology of the fœtal and infantile forms of this disease that: (1) The stages of cartilaginous ossification are normal up to the formation of the primary areolæ; (2) The periosteal and medullary ossification is quite abnormal in character, deficient in quantity, and inferior in quality (*Fig.* 389); and (3) Osteoblast edging to the trabeculæ is either absent altogether or only partially present in parts.

FIG. 389.—*Case* 3. Slightly magnified (× 2½) section from the lower end of a tibia, showing the very delicate framework of the cancellous tissue, the thickened periosteum, and the absence of the ordinary cortical layers.

The various changes in the cartilage—the proliferation of the cells, their arrangement in rows or columns, the increase in their size, the formation of the zone of provisional calcification and of the primary areolæ—are stages in the process of the production of a framework on which the bone is in the first instance to be laid down.

The real process of bone-formation begins with the penetration of the areolæ by the vessels of the medulla carrying with them their covering of

osteoblasts, i.e., of cells of connective-tissue origin, whose function is to arrange themselves along the calcareous walls of the areolæ and surround themselves with osseous substance. It is this process that defaults. The cells present in the medullary tissue do not arrange themselves in this way, and cannot therefore be recognized as osteoblasts; and the bone formed is not deposited in laminæ as it is when a layer of osteoblasts fringes the walls of the areolæ or the edges of the trabeculæ, but is the result of calcification of cartilage and the metaplasia into bone of the connective tissue of the marrow.

The observations that follow are derived from an examination of microscopical sections from *Cases* 1, 3, and 8, examples of the fœtal, infantile, and middle-aged forms of the disease; but for the adolescent variety I have had to fall back upon Looser's description in *Case* 7.

THE DISEASE IN THE LONG BONES.

If a microscopic section including an epiphysis and part of the diaphysis is made from a long bone of either a fœtal or an infantile case, certain characteristic appearances can be seen with the naked eye, or, better still, on slight magnification (*Fig.* 390).

1. The epiphysial junction is straight, regular, and sharply defined, any deviation from its straightness being so trivial as to be within the normal limits.

2. The zone of provisional calcification is complete and well marked.

3. In the adjacent part of the medullary cavity the trabeculæ are slender and delicate; their direction is mainly in the long axis of the bone, and they are widely separated by spaces filled with a delicate connective tissue or fibrous marrow, rich in cells and devoid of fat. The trabeculæ do not form a continuous network. Single trabeculæ, or patches of anastomosing trabeculæ isolated in an expanse of marrow, occupy a considerable area of the section.

4. The periosteum is thickened, and is much thicker than the perichondrium of the epiphysis.

5. There is no continuous layer of compact bone beneath the periosteum, but its place is taken by discrete trabeculæ whose direction, like that of those in the interior of the medulla, is parallel to the long axis of the bone.

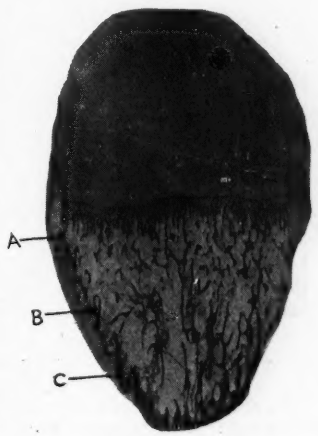


FIG. 390.—*Case* 3. Section of a rib, showing the costochondral junction, which is sharply defined. Very slightly magnified (× 2½). The next three photomicrographs were made from positions indicated by the arrows, but from a corresponding section. A, *Fig.* 391; B, *Fig.* 392; C, *Fig.* 393.

The microscopical appearances at different parts of the section may next be studied.

1. **The Formation of Bone from the Cartilaginous Epiphysis.**—The changes in the cartilage up to and including the zone of provisional calcification do not differ from those present in normal ossification from cartilage.

The provisional zone is well formed, lime salts being deposited in the strips of matrix separating the columns of cells, with great regularity. It is below this that the abnormal appearances begin (*Fig.* 391). Calcareous processes form across the space between the struts, and a number of superposed cartilage-cells become enclosed in a calcareous envelope. The capsules of the cells themselves may show signs of calcification. Groups of two or three of such compartments of enlarged cells (primary areolæ), lying side by side and incorporated in calcareous material, constitute the most recently formed trabeculæ. The further growth of such trabeculæ, which, however, is only slight, takes place by an extension of a granular calcareous deposit in the connective-tissue groundwork of the adjacent marrow, numerous cells being included (metaplasia). These cells are of considerable size, and the nucleus is surrounded with much clear cell substance. The spaces containing them are very numerous, large, and closely set, and with the persisting hypertrophic cartilage-cells, which can be traced far down into the medulla, form a conspicuous feature of the bone trabeculæ.

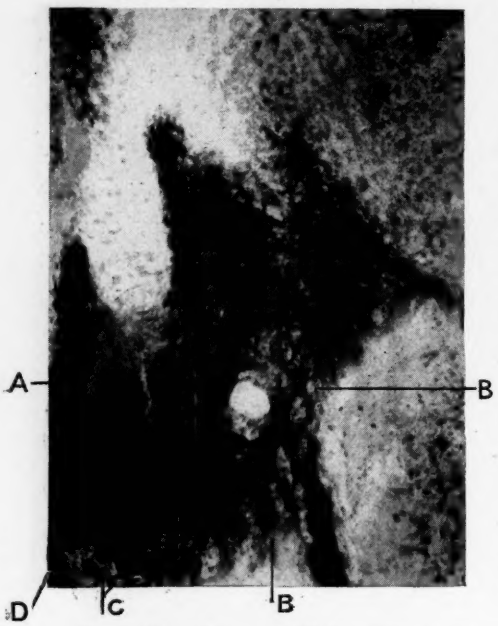


FIG. 391.—*Case* 3. High-power view (× 110) of trabeculæ beneath the periosteum just below the juxta-epiphyseal region (rib), showing: A, Adjacent columns of cartilage-cells from epiphysis; B. Advancing metaplasia of the marrow connective tissue into bone; C, Giant cells; D, Periosteum. The periosteum is immediately on the left of the trabeculæ, and sufficient of it is not included to enable it to be recognized. (*See Fig.* 390, A.)

THE FIRST MARKED DEPARTURE FROM THE NORMAL PROCESS OF OSSIFICATION IS THE FORMATION OF TRABECULÆ BY THE CALCIFICATION OF THE CARTILAGE, AND THEIR EXTENSION BY METAPLASIA OF THE ADJOINING CONNECTIVE TISSUE OF THE MARROW.

Intimately associated with this, and without doubt the cause of it, is THE SECOND IMPORTANT ABNORMALITY, VIZ., THE COMPLETE ABSENCE OF ROWS OF OSTEOBLASTS.

2. The Formation of Bone under the Periosteum.—The periosteum is seen to be considerably thickened, and its deeper layers are composed of very elongated cells with flattened nuclei. These pass gradually into the cells of the marrow and lose their flattened elongated appearance. This portion of the periosteum has been called the cambium layer. Where bone-formation is taking place, the cellularity is markedly increased.

The trabeculæ are formed by metaplasia (*Fig.* 392), lime salts being slowly deposited in the connective-tissue fibrils between the cells after they have assumed a rounded form. In this way a trabecula may be forming, on one side from the under surface of the periosteum, and on the other from the medulla. The cells engaged in this process are large, and may lie closely packed together with very little intercellular substance. As they are

incorporated in the bone, the trabecula becomes honeycombed with cell spaces as closely set as the apertures in a piece of perforated zinc.

The character of these cells is remarkable. In *Case* 3 many trabeculæ immediately abutting on the periosteum, and clearly originating in connection with it, present appearances very suggestive of the presence of included cartilage-cells. Here and there groups of spherical cells, unmistakably cartilage, may be seen lying against a trabecula on its periosteal side and in process of inclusion (*Fig.* 393).

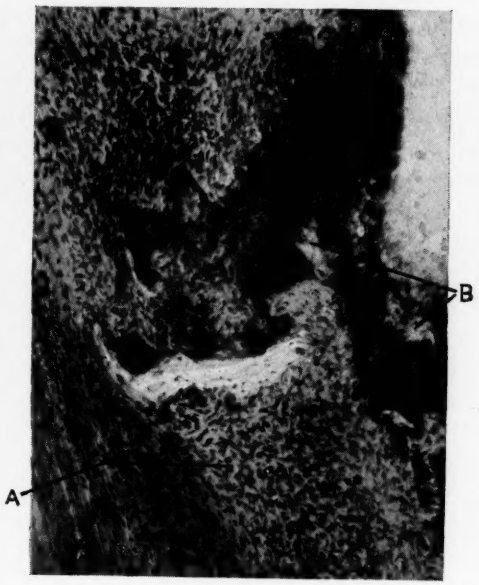


FIG. 392.—*Case* 3. High-power view (× 110) from rib. (*See Fig.* 390, B.) Trabeculæ forming in the deep layers of the periosteum by metaplasia. A, Periosteum; B, Cartilage-cells.

[All the photomicrographs are from untouched plates.]

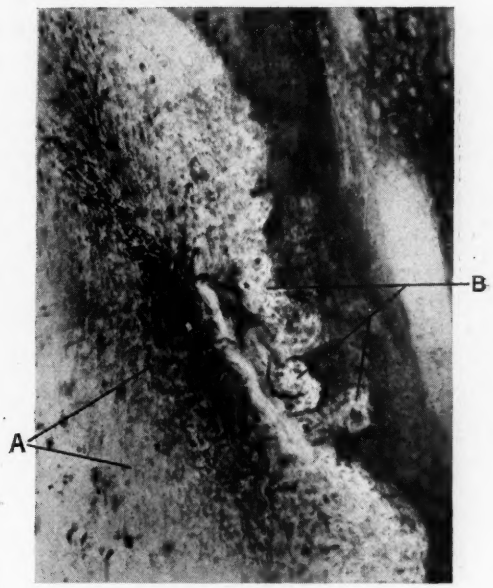


FIG. 393.—*Case* 3. High-power view (× 110) from rib. (*See Fig.* 390, C.) Cartilage-cells lying against a trabecula on its periosteal surface, and being included in it. The cellularity of the periosteum at this point is very marked. A, Periosteum; B, Cartilage-cells.

In *Case* 1 the section shows a very clear transition from the deeper cells of the periosteum to cartilage-cells closely fitted together.

In both cases (1 and 3) the cartilage cells arising from the periosteum are well seen at a considerable distance from the epiphysial line. There is no possibility of any doubt as to their periosteal origin.

THE THIRD IMPORTANT DEPARTURE FROM THE NORMAL IS THE PRODUCTION OF CARTILAGE-CELLS BY THE PERIOSTEUM, INSTEAD OF OSTEOBLASTS (*Fig.* 394). It is the outstanding feature of the subperiosteal ossification. The cells appear to retain their cartilaginous appearance after incorporation in the trabeculæ, and become surrounded with lime salts, assuming apparently some part of the osteoblastic function; but the osseous tissue resulting differs in appearance and in amount from that produced by the true osteoblast.

Klotz,[12] who has described with great clearness the histological appearances in the case of a full-time child who lived only five minutes, drew

particular attention to this development of cartilage cells from the periosteum, and suggested the following interesting explanation.

In its earliest form the fœtal bone is composed of cartilage. Ossification begins in the centre of its shaft, and gradually advances until only the ends of the bone retain their cartilaginous character. A membrane—the perichondrium—surrounds the cartilaginous shaft, and cartilage-cells grow on its inner surface. As the shaft commences to ossify, the membrane overlying the bony portion thickens and increases in vascularity, and the cells in its deep layer proliferate and form osteoblasts. It then becomes periosteum. In the cases now being considered, Klotz points out that the periosteum retains its early fœtal function of producing cartilage-cells; but he seems to hesitate to look upon them as cartilage-cells pure and simple, and would place them midway between cartilage-cells and osteoblasts.

FIG. 394.—*Case* 3. A low-power view (× 30) having the part shown in *Fig.* 393 in its centre. It shows the porous character of the trabeculæ formed in osteogenesis imperfecta, and an early deposit of lime outlining rounded cells across a medullary space. The relation of the periosteum to the trabecula is clear.

Returning, after this digression, to the histology of the cases specially examined, it may be noted that the special feature in *Case* 3 was the extremely atrophic condition of the trabeculæ. In *Case* 1 the subperiosteal cartilage-cells were very numerous, and passed between the trabeculæ in a compact arrangement into the medulla (*see Fig.* 383). They were identical in appearance with the cartilage-cells of the epiphysis just above the provisional calcified zone in the same section (*see Fig.* 382). The marrow, where it was less cellular, showed a delicate fibrous structure, and the fibres had a tendency to sweep round the ends of the trabeculæ and the sides of concavities. In neither case was fat present in the marrow in any of the sections. Finally, the trabeculæ, whether of epiphysial or periosteal origin, were calcified throughout; osteoclasts were present in fair numbers, but resorption was not thought to be abnormally active.

The adolescent form of the disease (fragilitas ossium) presents some suggestive differences from the above. Its salient features emerge from a study of Looser's careful examination of *Case* 7.

a. The trabeculæ of the spongy tissue of the medulla were very delicate and small. The cortex of the shaft was excessively thin and porous, and appeared on section, not as a continuous layer, but as a great number of smaller or larger irregularly-shaped trabeculæ.

The marrow was largely fatty—fat-cells even extending into the deep surface of the periosteum between the gaps in the cortical trabeculæ. Its vascularity was slight.

b. A more normal type of ossification was found at the epiphysial disc. Processes of marrow, carrying cells, penetrated the cartilage, and rows of osteoblasts formed upon the struts of the calcified zone. This, however, was only partial. The trabeculæ generally carried a regular edging of osteoblasts. It was evident, however, that the osteoblasts did not function in a normal manner. Only a very small amount of osseous substance was deposited around them, so that the trabeculæ contained numerous cell spaces. They were also striped and lined, strongly suggesting a lamellar system; but the bone substance had a more or less crumbling appearance. Evidently the evolution of the osteoblast had made very definite progress, but that cell had not yet reached the stage of the finished article.

FIG. 395.—*Case* 8. Man, age 68. Section from the head of the femur (× 4½). The atrophic trabeculæ are maintained in position by the celluloidin: A, Calcareous débris.

The middle-aged or senile form.—Still other appearances may be seen in later life. A section was taken from the head of one femur in *Case* 8. In order to maintain the parts *in situ* it was necessary to preserve the celluloidin in which the specimen was mounted for cutting.

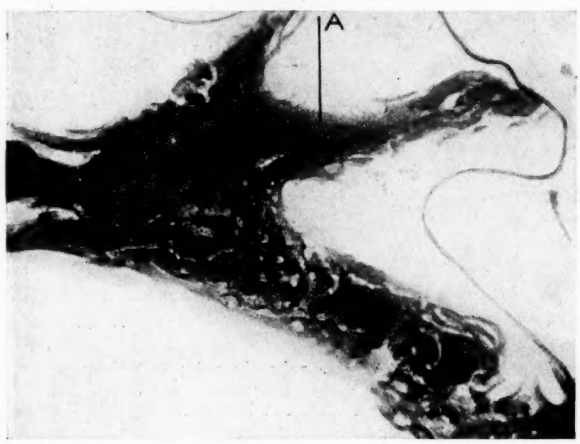


FIG. 396.—*Case* 8. A broad trabecula from a corresponding section to that shown in *Fig.* 395 (× 30), showing rarefactive absorption: A, Minute pitted appearance, due to cell spaces.

It shows to the naked eye a few thin red lines of bone (eosin stained) traversing the section, and at the surface forming a very delicate widely-spaced network. Under the microscope (*Fig.* 395) these lines show as slender elongated bone trabeculæ, having a fibrous laminated structure in some parts, and a certain resemblance to normal laminated bone in others. Where the section is thin, a very finely pitted appearance is seen, due to the closely aggregated cell spaces. The larger trabeculæ show a curious condition. An irregular excavation of the surface is mapped out in the form of channels, hollows, holes, and shallow spaces. The excavations are sharply bordered by the more deeply eosin-stained thicker parts; but occasionally the edge is shelving. The whole trabecula presents the finely pitted appearance

just described, as well as larger spaces. Evidently the bone substance is disappearing rapidly, and not by the ordinary process of giant-cell absorption.

The spaces separating these attenuated trabeculæ show a tracery of faintly delineated circles suggestive of fat-cells; and scattered in parts of this tissue are groups of granules and spherules of lime, staining deeply with hæmatoxylin. These appearances seem to indicate that, during the period of healthy life, bone-formation assumed an approximately normal character (compare the adolescent form); but when relapse occurred, not only did the waste fail to be made good, but, with age and increasing decrepitude, rarefactive absorption became very pronounced (*Fig.* 396). That process would be facilitated by the abnormal architectural and crumbling character of the osseous substance peculiar to this affection. Finally, the disappearing bone and marrow reached a condition of adipocere (first of fat, which later became saponified), in which traces of the osseous débris can still be detected, although the section is a decalcified one.

THE DISEASE IN THE SKULL.

A section cut from a part of the calvarium of *Case* 3 (*Fig.* 397), where it was very thin, showed bone of two very different characters. The prevailing formation was granular and not laminated, and numerous cells of peculiar appearance were evenly distributed through it. Larger than ordinary bone-

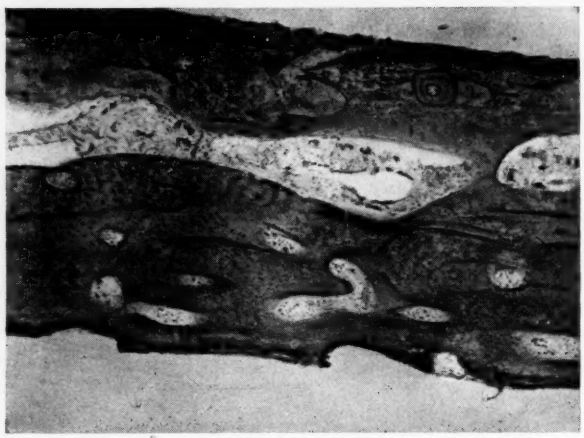


FIG. 397.—*Case* 3. Section through a thin portion of the calvarium (× 50) showing two kinds of osseous tissue: A, A granular type of bone containing many cells and not laminated; and B, A laminated form in immediate relation with the lacunæ.

cells, of a rounded or angular shape, and having a large deeply staining nucleus in the centre of a clear zone, they would have been regarded as cartilage-cells in any but a membrane bone.

A number of lacunar spaces were also present in this section. They were filled with a myxomatous marrow, and here and there was a very partial attempt at an edging of osteoblasts, rarely amounting to more than a few cells. But these spaces were surrounded by zones of almost normal-looking laminated bone, which by reason of their different architecture, their fainter

staining, and their more or less circular shape, contrasted strongly with the granular many-celled bone in which they were placed. Some, when the lacunar space was almost obliterated, were as conspicuous as knots in a plank.

Where the skull was thicker (*Fig.* 398), much of this granular bone was replaced by the laminated form, so that the latter predominated. Large diploic spaces had formed, which were filled with normal marrow, and in places their boundaries were fringed with osteoblasts. Both tables were developing. Clearly in certain parts of the calvarium there were indications of a tendency to a recovery of function on the part of the bone-forming cells.

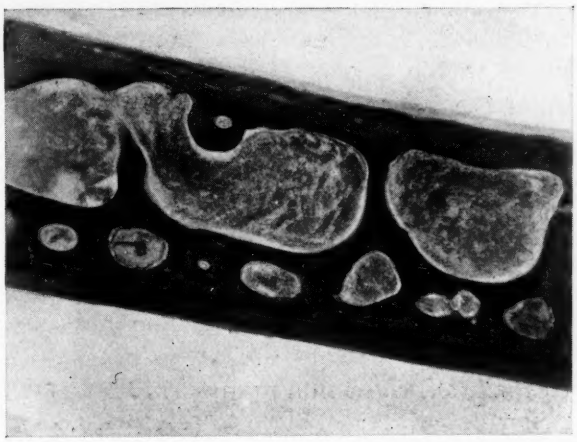


FIG. 398.—*Case* 3. Section through a part of the vault where the bone was thicker than in *Fig.* 397 (× 30). A diploë is forming, and both tables are developing. The character of the bone is more normal. It shows lamination. Hardly a trace of the granular non-laminated bone seen in *Fig.* 397 can be detected.

It would appear, moreover, that recovery had been complete in the skull of *Case* 8 (age 68 years), for a section showed normal laminated bone, and a relapse of thirty-eight years' duration had failed to impair its effects. Yet the morbid process had been active during the period of ossification, for its traces are seen in the increased bitemporal diameter and the numerous Wormian bones.

Two points of some interest arise in connection with these histological observations: (1) *The relation of the cartilage-cells to the calcareous deposit;* (2) *The nature of the bone formed.*

1. **The Relation of the Cartilage-cells to the Calcareous Deposit.**—The formation of the provisional calcification zone has been so taken for granted as a natural phenomenon that the cause of its formation has not excited curiosity. It is conceivable that it is part of the function of a cartilage-cell at a certain stage in its life-history to surround itself with lime; but this may really be an example of the accepted teaching that lime salts are apt to be deposited in a tissue that is dead or almost dead.

In favour of this latter view is the fact that the cartilage-cells swell up just above the zone, and speedily disappear below it when osteoblasts are

carried amongst them by the marrow processes. In osteogenesis imperfecta where no osteoblasts are present to be carried amongst them, the calcareous deposit extends, and groups of swollen cartilage-cells become entombed in a calcareous mass, whilst even the capsules of the cells may show signs of calcification. The cartilage-cells that develop from the periosteum are not a normal production, but they also become surrounded with lime when they have arrived at maturity, and as many of the cell spaces in the trabeculæ are empty, it is probable that their life is a short one. Hyaline cartilage is, in the main, a transitory tissue.

The cartilage-cell has a much lower vitality than the osteoblast. The latter becomes a bone-cell, and as such helps to maintain the bone's nutrition, and probably, when liberated, as in fracture or in tabetic joints, exercises a considerable influence in the development of fresh osteoblasts.

2. **The Nature of the Bone Formed.**—The distinctive histological features of the bone-formation have been considered. The fragile character of the bones depends upon: (*a*) The absence of cortex, or its fragmentary nature and exceeding thinness when present; (*b*) The sparse delicate and widely-separated trabeculæ, honeycombed by closely-set cell spaces; and (*c*) The nature of the osseous substance.

The latter is formed by the deposit of calcareous granules in the very limited connective-tissue stroma separating the cells. Consequently the hard material between the cell spaces is much less in amount than in laminated bone formed by osteoblasts, whilst in appearance it is less densely compacted. Such bone would offer but little resistance to resorption, especially if the cells it contained were either dead or of very impaired vitality; and there can be no doubt that resorption of the feebly constituted bone is not a negligible factor in the production of the atrophic conditions of the disease. There is evidence to show that it may occur without the intervention of giant cells (*Case* 8) in the senile form, and even in the earlier varieties of the disease it is not improbable that resorption by osteoclasts, and disintegration without them, go on together. It would be difficult otherwise to account for the extreme tenuity of the trabeculæ in spite of the osseous metaplasia of the delicate marrow.

PATHOGENESIS.

The absence of osteoblasts, and the formation of cartilage-cells from the periosteum, instead of osteoblasts, are the two most suggestive histological features in osteogenesis imperfecta. How are they to be explained?

If the pathogenesis of blue sclerotics is to be linked up with that of osteogenesis imperfecta, it is necessary to go back to the connective-tissue cell, or even to the mesoblast cell which precedes it.

Fibrous tissue, cartilage-cells, and osteoblasts are specialized forms of connective-tissue cells, and each is found in places where it is specially adapted for the work that has to be done. We do not know what determines the development of fibrous tissue, of the cartilage-cell, or of the osteoblast, from the connective-tissue cell under normal circumstances; but environment is probably of considerable importance, and the evolutionary influence of function is not to be overlooked.

Now, in the disease under consideration, something goes wrong in the evolution of the osteoblast, and a cell of poor vitality and one functionally less well adapted for good bone building, i.e., the cartilage cell, is produced in its stead (*see Fig.* 383). This fundamental error of evolution is responsible for the affection known as osteogenesis imperfecta.

In the absence of the requisite knowledge, an intelligible theory, even if there is but little to justify it, may at least help to a better appreciation of the disease, which, it must be admitted, is not easy to understand. We may conceive the affection to have its origin either: (1) *In a quality implanted in the connective-tissue cell itself at an earlier period of its development*, and destined to influence its future evolution unfavourably; or (2) *In some influence acting upon the cell from outside*, and not of necessity directly.

It is possible that both causes may play a part.

1. **An Intrinsic Cause.**—In a previous lecture[13] I have discussed the frequency with which one tissue or organ of the body is apt to degenerate earlier than the rest, or proves to be less able to resist harmful influences, and how this delicacy of tissue is not infrequently manifested in more than one member of a family or handed on to the offspring. If we recognize, as we must, the possibility of the existence of such defective vitality in some particular tissue or organ, it would seem easy to concede it to the cells of which they are composed or from which they are developed.

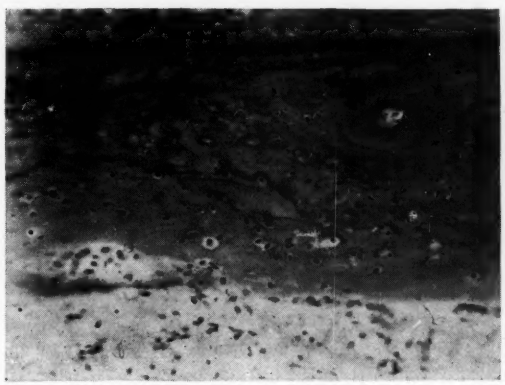


FIG. 399.—*Case* 3. High-power view (× 150) of cranial vault, showing the character of the cells included in the forming bone. The resemblance to cartilage-cells is marked.

Let us then suppose that a certain weakness, defect, or want of stamina is engrafted upon certain mesoblast cells, or upon the connective-tissue cells themselves a little later in the growth of the embryo. They may have sufficient vital force to carry them through certain stages of their evolution, but not enough to enable them to form their more highly specialized products in full perfection. Thus in one direction the fibrous tissue formed may be of poor quality (blue sclerotics, liability to sprains); in another, when called upon to produce osteoblasts, they are unable to do it, but put forward the cartilage-cell as the best they can do in that line. Osteogenesis imperfecta is the result.

There can be little doubt that the evolution of the cell is largely dependent upon or influenced by its environment. What the environment does, or how it does it, is at present quite concealed from us. Extrinsic influences no doubt come into play; but the cell itself must contribute something to the evolutionary process. If it lacks vitality, if it fails in point of stamina, the process will almost certainly be influenced unfavourably.

One of the most arresting of the histological phenomena was the cartilaginous appearance of the cells in the skull sections. There is no question here of the membrane, in which ossification occurs, retaining its fœtal function. Cartilage-cells are not at any time formed normally in the membrane bones; and that fact raises a doubt as to whether the cells are really cartilage-cells. There is not, however, sufficient justification for the doubt. If the connective-tissue cell has not sufficient vitality to go on to the evolution of the osteoblast, we might expect it to default in the membranous cranial bones as well as in the long bones. If it produces the next best thing in the latter, it might surely be allowed to do the same in the former (*Fig.* 399).

In connection with this point it is interesting to note that a tendency towards recovery appears more quickly in the skull, and advances further and is more lasting, than in the long bones.

2. **An Extrinsic Cause.**—The other possibility is that the disease may arise in some obscure way by the failure of an external influence normally brought to bear upon the cells which are destined to develop osteoblastic functions.

The well-established connection of the anterior lobe of the pituitary, the thyroid, and the testicle with bone growth has naturally caused attention to be directed to the possible association of one or other of the internal glandular secretions with osteogenesis imperfecta. It is thought that these secretions, which no doubt are carried by the blood-stream, may exert an indirect rather than a direct effect—that they may stimulate other cells within the bone to form hormones which may in their turn act upon the bone-forming cells themselves.

There is very little to support this idea in the case of osteogenesis imperfecta. In a few cases thyroid peculiarities have been noted; but no definite alteration in any of the glands credited with the formation of internal secretions has been found except in very occasional cases. Consequently, until more is known on this somewhat vague subject we may regard the association as accidental.

On the other hand, there is an objection of some moment to the hormone theory.

In those instances in which the action of hormones has been established, it is fully-developed and often functioning cells that they stimulate to activity. Secretin may be taken as an illustration. Secretin is formed when acid stomach contents pass over the duodenal mucous membrane, and, when conveyed by the blood-stream to the pancreas, stimulates the pancreatic cells to secrete. Moreover, the influence of the internal secretions upon bone-growth so far as it is known is connected with their probable effect upon healthy, normally developed cells (acromegaly, cretinism, eunuchs). Now in osteogenesis imperfecta the fault is one of evolution—cartilage-cells are produced when osteoblasts ought to be, which is quite a different state of affairs.

The intrinsic theory as an explanation is simple and easy to understand, and there is more to be said in favour of it than for the extrinsic—at any rate at the present time.

TREATMENT OF THE CONSTITUTIONAL STATE.

If the cause of the failure of the connective-tissue cell to develop into an osteoblast is due to a want of stamina on the part of the cell, the indication is clear, viz., to promote health in every possible way by such general measures as are adopted in the case of delicate and poorly developed children. The life-history of Dr. Ormerod's case (*Case* 8) is valuable evidence of the good that may result from favourable conditions of life, and of the ill effects that may follow their withdrawal. The improvement produced by dietary and hygienic treatment in Looser's case (*Case* 7) is also worthy of note. But when the affection is pronounced as in many of the infantile cases, nothing is known to do good (*Case* 2, Poynton's).

It would have been impossible for me to have worked out my subject without much kind and generous help from Sir Arthur Keith, Professor Shattock, Mr. Tyrrell Gray, Dr. G. H. Rodman, and Dr. Donald Paterson, to name those to whom I am most indebted. To them and to several others, most of whom I have mentioned in the text, I tender my most grateful thanks.

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THE TREATMENT OF SIMPLE PAPILLOMA OF THE BLADDER BY FULGURATION.

By W. GIRLING BALL, London.

Although the endoscopic method of treatment of simple papillomata of the bladder by high-frequency currents was introduced by Beer, of New York, so long ago as 1910, and many subsequent writers on the subject, including Thomson-Walker in this country, have written excellent descriptions thereof, its advantages do not appear to have been appreciated sufficiently to lead to its universal adoption. The reasons for believing that trans-urethral diathermic cauterization should replace the older procedure of suprapubic removal in selected cases may be summed up briefly as follows. In experienced hands it is usually easy of application; the patient seldom requires to remain in bed for more than forty-eight hours, if at all—a point of considerable importance as compared with the weeks required for recovery from a suprapubic cystotomy and its possible complications; there is less liability to the production of cystitis and its attendant evils: the likelihood of a recurrence of the growth, or of re-formation in other parts of the bladder, is diminished; the operation can be performed under local anæsthesia applied to the urethra in cases in which a general anæsthetic is either unnecessary or undesirable; and, lastly, in those patients who have already been submitted to suprapubic excision, small recurrences can subsequently be readily kept in check.

The object of this paper is to describe the method as I have used it, and to illustrate it with the appearances seen at the time of the operation, and the changes observed as the result of such treatment.

The high-frequency machine used in the earlier cases was that supplied by Schall, which worked very satisfactorily, but it had the disadvantage of being cumbersome and non-portable. More recently the instrument supplied by the Genito-Urinary Manufacturing Co. has been used with equal effect. This machine has the advantages, amongst others, of being portable, is supplied with an excellent foot-switch which enables the operator himself to make and break the current, and of working off a constant current of various voltages.

The active electrode consists of a wire with a platinum or copper tip about eight inches long, covered with insulating material of such thickness as to render the whole calibre as large as that of a No. 6 ureteric catheter.

The indifferent electrode is a metal plate (6 in. by 8 in.), which, wrapped in a towel soaked in 10 per cent saline in order to keep even contact with the skin, is placed over the suprapubic region; this pad should be kept moist throughout the operation.

The desirability or otherwise of performing the operation under an

anæsthetic is a matter of some importance; it varies with the practice of different surgeons. It has been my custom to carry out the treatment under general anæsthesia, even in the case of small growths. The reason for adopting this attitude has been that under these conditions a repetition of treatments has often been avoided; some growths have been destroyed at a single sitting, which otherwise would have required a number of treatments; much larger growths have been treated by this means which might have had to submit to suprapubic removal. Repetitions of treatment are sometimes required even under a general anæsthetic, but are more frequently necessary if only local urethral anæsthesia is used; under the latter, the sensitiveness of the urethra or the irritability of the bladder prevents the retention of the catheterizing cystoscope for the prolonged treatment required for the effective destruction of the growth; moreover, pain due to the accidental touching of the normal mucosa by the terminal is sometimes troublesome. As a general rule it may be said that a general anæsthetic is not a necessity for the treatment of small growths, or even the larger if the patient is prepared to undergo a number of treatments, but that on the whole its use is desirable.

Having introduced the catheterizing cystoscope into the bladder, which is distended with 12 oz. of sterile water, an accurate survey of the growth or growths is made, especially with regard to size, number, and position; their frequent close relationship to the ureteric orifice renders this liable to damage; its position therefore must be carefully noted. The nature of the growth must be defined, due attention being paid to the history, its cystoscopic appearance, and other clinical findings. Sometimes it is difficult to distinguish between simple and malignant papillomata. If a bladder growth shows definite evidence of malignancy, in my opinion this method of treatment should not be adopted, but a partial cystectomy advised; it is impossible to estimate the degree of involvement of the bladder wall from the cystoscopic appearances, and it is for this reason that the method seems to be contra-indicated. Fulguration is chiefly applicable to those growths possessing definitely benign characters. In some doubtful cases it may also be used, and with beneficial effect; the results of the treatment may, however, lead one subsequently to doubt the innocent characters of a particular growth: a point which will be referred to later. If the treatment leads one to think that the growth possesses malignant characters, this method should not be persisted in.

The method of attacking the growth must next be decided on. As a general principle it should be laid down that the surface of the growth should be first destroyed. It is generally thought, and there is some proof of it, that vesical papillomata are capable of forming implantation growths on other portions of the bladder wall.

The less frequent recurrence of papillomata treated by this method, as compared with those otherwise dealt with, is presumably due to the fact that the cells are destroyed prior to their spilling on the normal mucosa. The complete destruction of the smaller growths should always take place from the surface, thus maintaining the advantage that only dead portions of the growth fall on to the base of the bladder.

In the case of very large pedunculated growths this is not always possible; it may then be feasible to attack the pedicle and burn it across; the growth thus detached from the bladder may subsequently be washed out through a Bigelow's evacuator if it will not come out through the cystoscope; it may be possible in some cases, when the pedicle cannot be seen owing to the over hanging villi, to burn away the front portion of the growth and then proceed as above.

In the earlier method of treatment by high-frequency currents as recorded by Beer, Judd, and Fullerton, the terminals were not embedded in the growth, but cauterization was produced by sparks shot at the growth from a distance. Diathermy, however, requires that the terminal should be embedded in the growth, the tissues being destroyed by coagulation, which leads to subsequent sloughing, ulceration, and healing. In all the cases that have come under my care this form of treatment has been adopted.

Having determined the mode of procedure, the active terminal is passed through the cystoscope and is made to approach the growth, into which it is embedded; the current is then turned on by the use of the foot switch; the current should not be allowed to pass unless the terminal is in contact with the growth; the site of the burning must be kept in view during this procedure.

DESCRIPTION OF FIG. 400.

(A) Shows the papilloma before treatment was commenced. (B) A close view of the approach of the terminal to the growth. (C) The terminal is embedded in the growth. (D) Coagulation taking place with the current turned on. (E) The appearance at the completion of the operation. (F) The appearance as seen a fortnight later. The ulcer had healed a fortnight later, and at the end of three years there had been no recurrence.

The tissues in close relationship to the terminal are first noticed to whiten as the result of coagulation, which spreads in all directions the longer the two are in contact. This is followed by the liberation of a number of bubbles, accompanied by a hissing sound which can be heard through the cystoscope; sparks are then observed to fly owing to the bad conduction of the tissues, which by this time have become blackened and charred. The process should be stopped by switching off the current as soon as the bubbles appear. At this stage the terminal can be withdrawn without any adhesion of the growth. When the tissues become charred, the current becomes ineffective on the deeper tissues, and the terminal sticks to the growth; this may have the advantage of allowing portions of the undestroyed growth to be torn away with it when it is withdrawn, and thus aid in its more rapid destruction; but this of itself may be disadvantageous as being productive of hæmorrhage, which, although small, may be sufficient to interfere with further progress; moreover, it allows some of the living cells to come in contact with the normal mucosa, which, as has already been stated, should be avoided as far as possible. After withdrawal of the terminal it is embedded into a fresh portion of the growth, and the process is repeated until the whole of it has been destroyed, down to the base of the pedicle; this must now be attacked and coagulated, together with a small area of normal mucosa round its base. Experience

FIG. 400.

alone will gauge the extent to which this is required; but it is difficult to do serious damage when it is realized that the penetration of the current is probably no more than the diameter of the terminal, which in this instance is very small.

FIG. 401.—Illustrates (A) a small growth, its pedicle, and the surrounding mucosa, treated at one sitting, with (B) the appearances seen at the end of the operation. The slough of the growth came away in one piece at the end of a week, leaving an ulcer which had completely healed a fortnight later. At the end of six years there had been no recurrence.

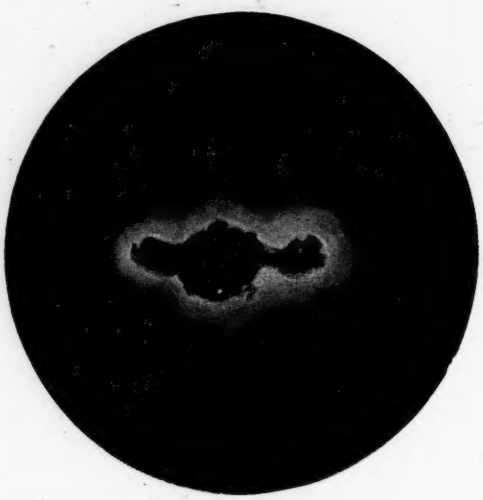

FIG. 402.—Illustrates the appearance seen after cauterization of three small papillomata situated in close relationship to each other. The charred remains in the centre are the destroyed pedicles. The neighbouring mucosa shows a small area of superficial coagulation. This is a typical appearance seen after destroying the smaller growths.

As with each application of the terminal a certain amount of débris is formed which falls into the surrounding fluid, it becomes necessary to empty and refill the bladder frequently; this, in addition to keeping the view of the

proceedings clear, has the advantage of maintaining the distending fluid at an even temperature, and of permitting the cleansing of the terminal, which becomes corroded with adherent growth (sometimes scraping with a knife is required). Portions of broken-off, undestroyed growth, which almost inevitably come away despite precautions to the contrary, can be collected for microscopic examination if thought desirable, although the information is seldom sufficient to distinguish between innocency and malignancy.

All the above-mentioned changes are shown in *Fig.* 400.

Hæmorrhage seldom occurs during the operation unless, as has already been mentioned, untreated portions of growth are torn off by adhesion to the terminal; should it do so, and the bleeding vessel can be located, the application of the electrode to that spot will suffice to stop it in the majority of cases. The application of hot water with the addition of adrenalin is all that is required if this method fails.

FIG. 403.—Illustrates a growth (A) with the appearances (B) seen a fortnight after the fulguration. There is a white slough at the site of the pedicle base, and an area of coagulated normal mucosa around it still showing. A small portion of untreated growth is seen at the top of the slough; this came away with the slough, leaving an ulcer which was completely healed when observed cystoscopically a fortnight later. This case was treated seven years ago, and there has been no recurrence.

Great care should be taken in washing the bladder repeatedly at the end of the procedure in order to minimize the risk of leaving small portions of living growth behind to act as potential implantation growths. Thomson-Walker advocates the use of weak solutions of silver nitrate (1–10,000) in order to destroy any vagrant cells. During the next twenty-four hours a little bleeding may occur; it never lasts longer; more often there is none at all.

The subsequent changes observed are those associated with necrosis of tissue elsewhere; a greyish-white or yellow slough forms at the site of the pedicle base, surrounded by an area of œdema which throws the neighbouring mucosa into folds or bullæ; this, again, is surrounded by an inflammatory

zone of varying width gradually fading off into the normal tissue. The slough separates at the end of ten to fourteen days, an event sometimes accompanied by slight hæmorrhage observed, as a rule, during one or two acts of micturition only; it is never severe or a cause of anxiety. The patient may be conscious of passing the slough if the pedicle was of wide dimensions. When seen a fortnight later, the resultant ulcer, dependent on the extent of the growth and the degree of destruction required, will usually be healed, and

FIG. 404.—Illustrates a large papilloma (A) dealt with at one sitting. (B) shows the appearances seen a fortnight later, demonstrating the characteristic œdema around the slough. (C) shows the condition of the bladder at the site of the papilloma fourteen days later. This case was treated eight years ago, and there has been no recurrence.

quite frequently not even a scar can be seen. In the best-treated cases not even a depression of the surface can be found. The whole process is apparently an aseptic one, for, with the exception of the occasional presence of blood, no abnormal constituents are found in the urine; bacteria are conspicuous by their absence, unless they have been present prior to the operation, which is rare with the benign type of papilloma.

In the case of large growths, second or even third sittings may be required, even if treated under general anæsthesia; the usual reason for this is that the operation becomes very tiring to the surgeon after it has lasted for two hours, a factor which constitutes one of the disadvantages of the method.

These secondary operations, in my experience, are not commonly required,

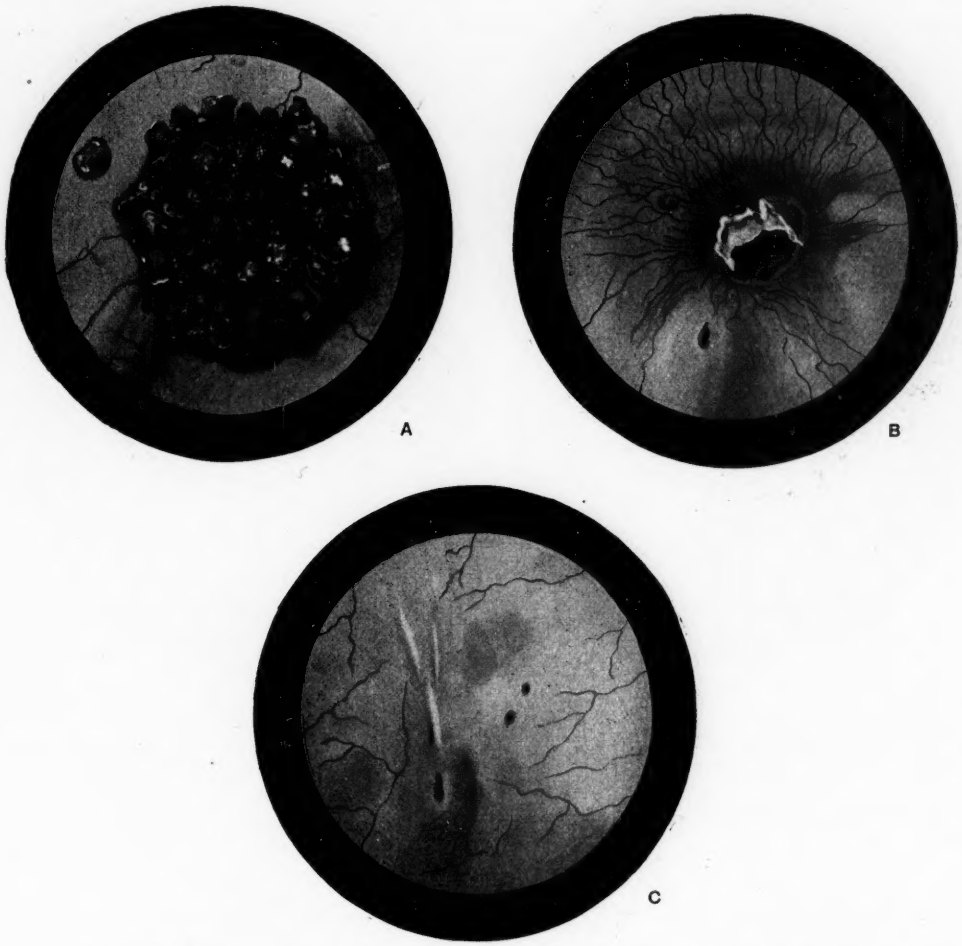

FIG. 405.—Illustrates (A) a large papilloma with a small one closely adjacent. (B) shows the appearances seen a fortnight after the treatment, and (C) after a further fourteen days. This growth was treated seven years ago; there was a small recurrence at the same site two years ago, which was dealt with by the same method, without subsequent recurrence.

and are usually only necessary in the case of those growths which in the first place might be considered by some to be too large for treatment by this method.

A month should elapse between successive treatments, so that all the sloughs may have separated and the healing processes have advanced as far as possible; the application of the current to necrotic tissues should be

avoided. It is very interesting to note how much the growth will shrivel if the burning is not completed at the first operation; occasionally this does not take place, in fact it may even appear to have increased in size; under these circumstances the suspicion of the existence of a malignant condition should arise, and a suprapubic removal should be advocated. The difficulty

FIG. 406.—Illustrates (A) a very large papillomatous mass composed of five different segments, which was successfully dealt with. The process of destruction took two hours. (B) shows the condition of affairs as observed a fortnight after the first application; the slough is seen with a portion of growth; this was cauterized with the result shown in (C), a fortnight later. This case was treated seven years ago, and has had no recurrence at the site of this growth. Two and a half years ago another growth appeared on the opposite side of the bladder, which was readily dealt with without subsequent return.

of distinguishing clinically between innocent and malignant papilloma has already been referred to. The above-mentioned point was well illustrated in a recently-treated case in which the growth was considerably larger at the second sitting than when first seen; its subsequent removal proved it to be a carcinoma with early infiltration of the muscular coat.

Sometimes difficulty is experienced in destroying the base of the pedicle owing to the toughness of its structure; the effect of the coagulation of its surface and of an area for one-eighth of an inch of the normal mucosa around may have the desired result, but if this fails further treatment may be required.

The subsequent immediate history of these cases as a rule is uneventful. It is rare for the patients to experience any pain after the operation, beyond a certain degree of soreness during the act of micturition as the result of prolonged retention of the cystoscope in the urethra. In no case has a urethritis been set up. Occasionally there is pain referred to the tip of the penis at the end of the micturition, lasting for a few days, presumably caused

FIG. 407.—Illustrates one of the advantages of the method. Three papillomatous masses (A) were seen in the neighbourhood of the right ureteric orifice, which could not, however, be seen. A portion of the front growth was burned away, when a fourth small papillomatous mass was observed extruding from the ureteric orifice. (B) shows a close view of this. The bladder growths have been completely destroyed, and it can now be demonstrated that this papilloma is of ureteral origin, as it is sometimes withdrawn into its lumen.

by the œdema which spreads on to the trigone from the cauterized area. Cystitis is said to occur occasionally, but in my experience there has not been a single case; moreover, the urine has never shown evidence of infection.

The end-results observed are well illustrated in *Fig.* 405. In some of the other pictures similar appearances are seen, but the process of healing has not advanced quite so far at the time of the observation. At the end of two months it is usually difficult to find the scar. The mucosa sometimes becomes puckered, as shown in *Fig.* 408.

Forty-eight hours is the average time required for the patients to lie in bed, but in some cases it is not necessary for them to do so for a longer period than that required for recovery from the anæsthetic. On general principles the ulceration should heal more quickly if the patient rests for a

week while the acute inflammation subsides, and it is my belief that it does so. On the other hand, it has not been my experience that any harm has arisen when the patient has got up early.

It is of the greatest importance that the patient should be kept under observation. A cystoscopic examination should be made at least every three months after the growth has been destroyed and sound healing has followed. This is done for at least two years. Longer intervals are permitted after that period has elapsed without recurrence. Small growths can be so easily dealt with that it is worth it to the patient.

There are some difficulties met with during the operation. They chiefly relate to the size, position, and number of the growths. Fortunately, the majority of the papillomata are single, and situated near the ureteric orifices—a site easy of access; but those placed far back on the posterior wall, on the

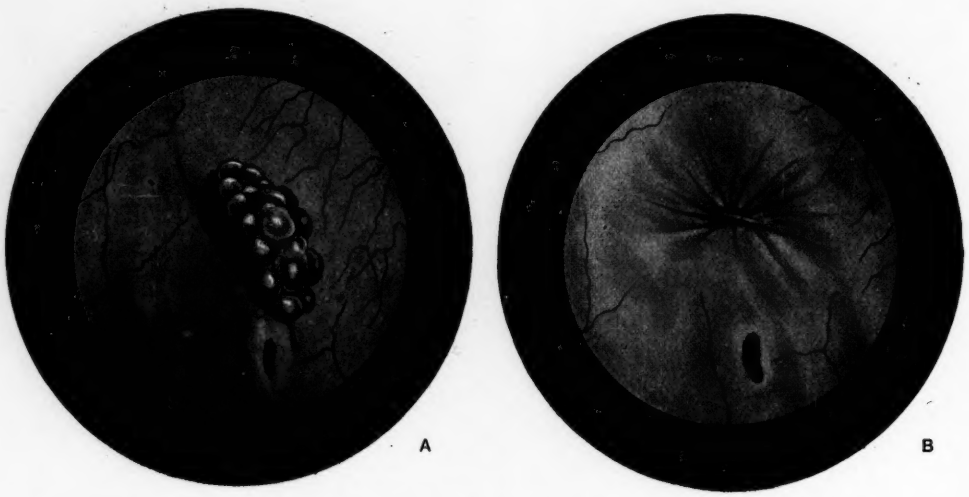

FIG. 408.—Shows a small papilloma (A), with (B) the appearance seen a fortnight after the fulguration. This was dealt with five years ago, and there has not been a recurrence.

vertex, on the anterior surface, and around the internal meatal orifice, are difficult to treat owing to their inaccessibility. The cystoscope of Swift Joly, with the recurved guide for the terminal, has helped to eliminate some of these troubles, but not all of them.

This method is not applicable to the treatment of very large growths, owing to the fact that the cystoscope becomes embedded amongst the villous processes almost immediately on entering the bladder, which completely obscures the view; moreover, even if they can be seen, and persistent bleeding does not result from the introduction of the instrument, the length of time required to burn them would be considerable. These have to be treated through a suprapubic incision, their removal being effected preferably by diathermic cauterization; subsequent cystoscopic observations will enable any recurrences to be dealt with in the early stages.

Multiplicity of growths does not of itself constitute a contra-indication to the method; among my cases is one of a man who had eleven papillomata,

all of small size, of which ten have been successfully dealt with; the eleventh growth presents a curious difficulty not met with previously; it is situated on the left lateral wall, at some little distance from the ureteric orifice; as soon as the current is turned on after embedding the terminal, the left leg kicks violently and throws the growth out of view.

At times the presence of an intravesical prostatic enlargement renders the growth inaccessible.

The presence of cystitis is a contra-indication, as the sloughing tissues constitute a fresh focus for infection. This, however, seldom exists with the innocent varieties of papillomata, although commonly associated with the malignant group, to which, as has been stated already, this method of treatment is not applicable.

Perhaps one of the greatest disadvantages of this method of treatment is the length of time required for the performance of the operation. The small growths can be quite readily dealt with; but if the growth is of any size a sitting may last a considerable period, depending not only on its dimensions, but also on the toughness of its structure. The advantages, however, so far outweigh those of suprapubic removal, that the trans-urethral method is to be preferred, and in my opinion should be used as the routine procedure for the treatment of innocent papillomata.

SHORT NOTES OF RARE OR OBSCURE CASES.

FOREIGN BODY IN THE APPENDIX.

By J. H. MATHER, Liverpool.

The following case is of interest on account of the nature of the foreign body, and as showing the value of X rays as an aid to diagnosis.

The patient, a woman, age 25, was admitted to the Royal Southern Hospital on Aug. 10, 1922, complaining of attacks of severe pain in the abdomen. For the past ten years she had suffered from intermittent attacks of pain in the right side of the abdomen, which were gradually becoming more frequent and severe. She had attended a hospital for women, and two years previously had been operated on for "misplaced womb and enlarged ovary". The patient stated that the attacks of pain persisted exactly as before the operation, and she continued to attend as an out-patient, receiving treatment for this obscure right-sided abdominal pain until her admission.

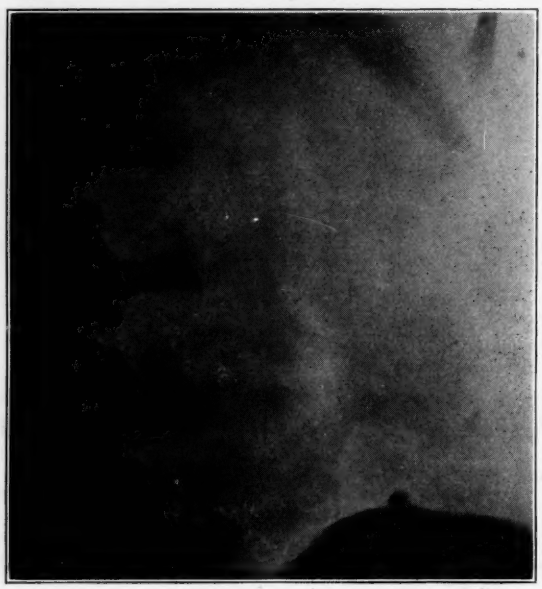

Fig. 409.

For the ten weeks previous to this she had approximately one attack each day, the pain being sometimes very severe. She had never vomited.

On examination the patient complained of pain on palpation in the right iliac fossa, the pain extending round to the loin. On Aug. 17, she was sent to the X-ray department for examination of the urinary tract for possible calculus. The radiographs showed both kidney shadows, not enlarged or displaced, and no stones were present. On the right side of the pelvis, however, at the level of the iliac crest a pin was shown, around the head of which was a shadow suggesting a concretion. This,

together with the fact that the pin changed its position in the two radiographs (*Figs.* 409 and 410), pointed to its being in the abdominal cavity.

A bismuth meal was then given, and, on examination of the abdomen twenty-four hours later, the pin could be seen just below the cæcum (*Fig.* 411). On palpation it could be moved with the cæcum, and a diagnosis of pin in the appendix was made.

FIG. 410.

At the operation Mr. Herbert Williams found the pin, the head with a surrounding concretion being in the lumen of the appendix; the pointed end had ulcerated through the wall of the appendix and was sticking into the iliacus muscle, the whole being surrounded by adhesions. The pin was very much corroded, and this, with the hard concretion, pointed to its having been in this position a considerable time.

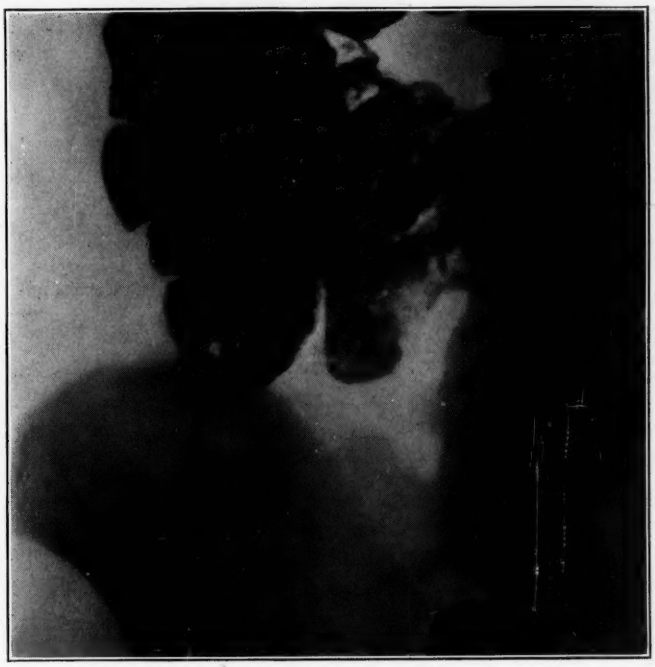

FIG. 411.

VOLVULUS OF THE STOMACH.

By HUMPHREY NOCKOLDS, London.

On May 11, 1923, a married woman, age 42, was admitted to Lewisham Hospital with the following history :—

She was said to have suffered from gastric ulcer when a girl many years ago, but had for years been quite well until fourteen days before admission. She vomited before getting up one morning. She got up and did her housework, but 'felt weak', and for the ensuing four days she vomited all her food, and then on the fifth day commenced vomiting continuously, anything she took being brought up at once. The vomit was watery and almost clear, containing no bile, and the quantity was greater than the volume of fluid taken in. She insisted on going on with her work. The day before admission she became light-headed, but was still refusing to go to hospital. By this

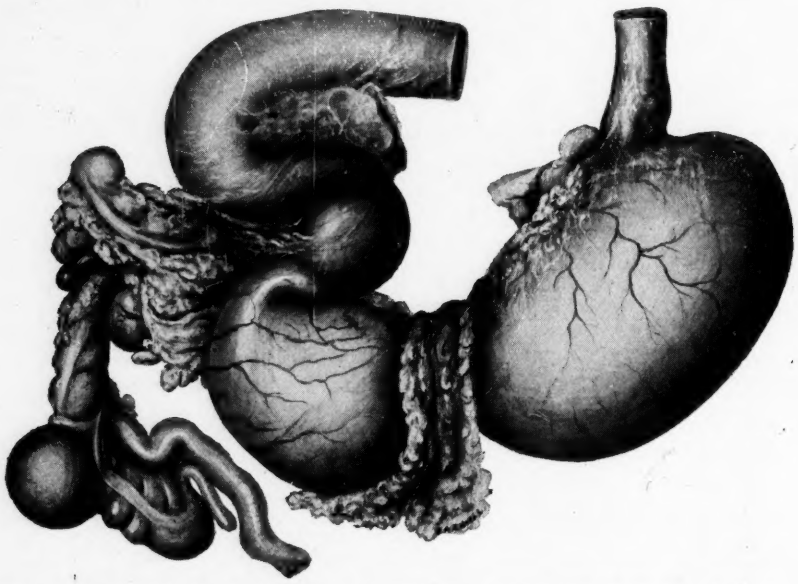

Fig. 412.—Complete rotation of lower portion of hour-glass stomach below an old healed ulcer.

time she was too weak to get out of bed. Dr. C. T. Comber, who was her medical adviser, saw her five days before admission, when she complained of acute indigestion, with pain and vomiting after food, and epigastric tenderness. She had absolute constipation for four days before admission.

On admission the patient was moribund and unconscious. Examination of the abdomen revealed nothing except an increase of the stomach resonance. The urine contained a fair amount of albumin. Temperature, 97·4°. Pulse small and running, 130. She died about twelve hours after admission, and it was thought that it might be a case of uræmia.

Post-mortem Examination.—When the abdomen was opened it was seen that the stomach was divided by a constriction into two portions, the upper

one being greatly dilated. The condition is well shown in *Fig.* 412. The upper segment measures 17 cm. (in the preserved state) and the lower segment 10 cm. in length. This constriction was partly caused by the rotation of the lower portion of the stomach about a vertical axis from left to right through 360°, forming a complete circle, the great omentum (which is extremely thin) being involved.

Examination of the inside of the stomach shows old healed ulcer on the lesser curvature giving rise to an hour-glass stomach, the lower portion of the hour-glass having rotated just below this ulcer. The lower turn has taken place about half an inch below the pylorus in the first part of the duodenum. The stomach wall of the upper segment is much thinner than the lower, which is intensely congested and has its mucous membrane bile-stained. Dr. J. W. McNee very kindly had sections cut for me from the old ulcer. They show much scarring and fibrosis in the submucous coat, but the mucous membrane has grown again over the site of the ulcer. The pylorus was thick and well developed.

An excellent account by Max Thorex of volvulus of the stomach appears in the *Journal of the American Medical Association*, August 25, 1923. According to this paper there appear to be recorded 31 cases of volvulus of the stomach, this case being therefore the 32nd.

Kocher in 1914[1] reports 28 cases. Since then there have been cases by Niosl, and Siegel and Thorex.

The specimen is in the museum of University College Hospital, London.

REFERENCE.

[1] "Ein Fall von Magenvolvulus", *Deut. Zeits. f. Chir.* 1914, 127, 571.

A CASE OF CARCINOMA OF THE BREAST: DEATH 13½ YEARS AFTER OPERATION FROM DIFFUSE SECONDARY DEPOSITS.

By CECIL P. G. WAKELEY, London.

This case is recorded because of the long interval between the time of the original operation and that of secondary deposits occurring in the liver; also because, once secondary deposits are clinically present in the liver, the average lease of life is about eighteen months. In this case the liver became enlarged and palpable in 1920, and death took place in October, 1923—that is, three and a half years later.

History.—The patient, E. D., age 36, was admitted to King's College Hospital under Mr. Burghard in May, 1910, with a hard tumour, about the size of a pigeon's egg, situated in the upper and inner quadrant of the right breast. It was stony hard and was attached both to the skin and the pectoral fascia. The patient stated that she had noticed a lump in the

breast for six months. On May 24 a radical amputation was performed; both pectoral muscles and the axillary glands were removed. The wound healed well. On section the growth was a typical spheroidal-celled carcinoma of the scirrhous type. The axillary glands were invaded with growth. The patient remained well until June, 1912, when a few secondary nodules appeared in the scar; these were excised, and were found to contain growth similar in nature to that of the primary focus which had been removed two years before.

In 1913 a few small glands were palpable in the axilla; these were excised, and on microscopical examination were found to be invaded with carcinoma.

In 1917 two small glands were noticed in the right supraclavicular triangle; these were completely removed, and on section were found to be invaded with malignant disease. The patient seemed in good health and undertook the work of a busy household.

In 1919 another gland was palpable in the supraclavicular region; it was situated just above the clavicle; on removal it was found invaded with growth. X-ray treatment was commenced in December; a pastille dose with a 1-mm. filter was given each week to the whole of the area from which the breast had been removed, and, in addition, one pastille dose was given to the supraclavicular triangle.

In February, 1920, the liver became enlarged below the costal margin, and secondary deposits could be palpated on its surface. Weekly treatments of one pastille dose were now given as regularly as possible both to the liver area and to the area of the right breast. The liver slowly increased in size, but the patient appeared to be very well and still continued her household duties.

In July, 1921, the liver was about three finger-breadths below the costal margin. The patient went away for two months to the seaside, and came back for further X-ray treatment looking very well.

In the middle of 1922 she developed a cough which proved rather troublesome. A skiagram of the chest did not reveal any secondary deposits. She went to Devonshire for three months and came back stating that her cough had disappeared. X-ray treatment to all areas was resumed; the liver had increased so that it was now five finger-breadths below the costal margin.

In July, 1923, the patient became blind in her left eye; this was thought to be due to a secondary deposit involving the optic nerve. In September ascites was first noticed. The fluid rapidly accumulated and, owing to embarrassment to the heart, paracentesis abdominis was performed on Oct. 2, 1923, 10 pints being withdrawn. The condition of the patient improved somewhat for a week, but coma supervened, and she died a few days later.

Post-mortem Examination.—At autopsy the liver occupied nearly the whole of the abdomen; it weighed 13 lb. 6½ oz. The whole of the surface was nodular. On section, patches of fatty degeneration could be seen between the nodules of growth. There was a small growth on the surface of the left lung. Both ovaries were enlarged, hard, and nodular, and each was about the size of a hen's egg. On section, areas of solid growth could be seen. The other organs were normal. An examination of the brain was not permitted.

MICROSCOPICAL EXAMINATION.—The liver revealed typical secondary scirrhous carcinoma. The nodule in the left lung revealed a carcinomatous growth of the scirrhous type infiltrating along the subpleural lymphatics. The ovaries showed extensive carcinomatous deposits of the scirrhous type.

The patient had received 248 pastille doses of X rays during the treatment, of which 125 were given over the liver area.

INTUSSUSCEPTION OF THE SIGMOID $3\frac{1}{2}$ YEARS AFTER AN INTUSSUSCEPTION OF THE APPENDIX.

BY A. J. BLAXLAND, NORWICH.

IN the BRITISH JOURNAL OF SURGERY of October, 1920, I recorded a case of intussusception of the appendix occurring in a man of 63. The appendix was completely inverted, its mucous surface being studded with malignant

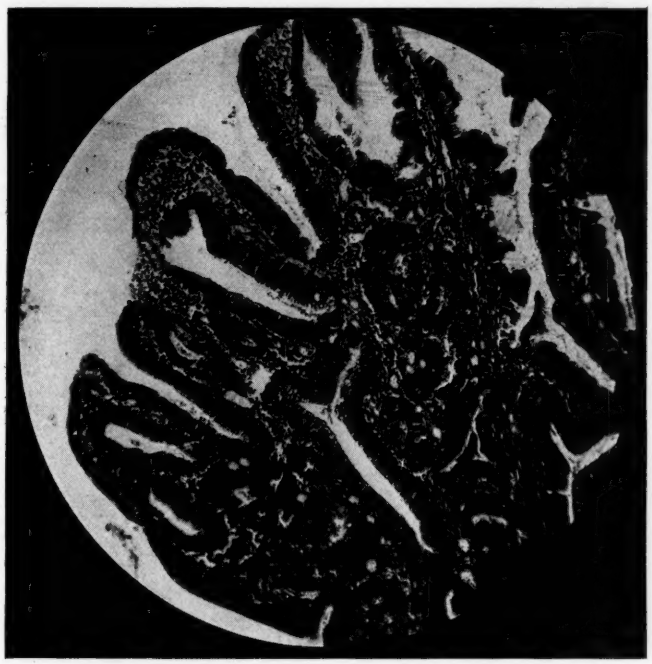

FIG. 413.—Malignant papilloma of appendix. (× 15.)

papillomatous growth, and it was lying within the transverse colon, having drawn up the ascending colon, the cæcum, and part of the ileum with it. The intussusception was reduced, with the exception of the appendix, which was removed by incising the cæcum round its base.

Three and a half years later, on Nov. 5, 1923, the patient was sent into the Norfolk and Norwich Hospital by Dr. Palin, of Fakenham, with intestinal obstruction of three days' standing, and passing blood per rectum. There was marked distention of the abdomen, and on rectal examination a swelling resembling an œdematous os cervicis could be felt high up.

Laparotomy revealed an intussusception of the pelvic colon. The bowel was invaginated for 6 inches, and after reduction, which was performed without great difficulty, the cause of the intussusception was found to be a protuberant malignant ulcer—about 1 inch in diameter—situated in the wall of the upper part of the pelvic colon. I performed a resection, closed the distal end of the bowel, and inserted a Paul's tube into the proximal end. Uneventful recovery ensued, except that during convalescence (as after his previous operation) he suffered from an attack of acute gouty arthritis.

The growth on section proved to be a malignant papilloma—similar in character, microscopically, to that which had affected the appendix, as is shown in the accompanying microphotographs (*Figs.* 413, 414). Apart from

FIG. 414.—Malignant papilloma of sigmoid. (× 15)

the rarity of a chronic intussusception of the large bowel occurring twice in an old man within a short time, the interest in this case seems to me to lie in the question as to whether the sigmoid growth was a primary one, or whether it was secondary to the papilloma of the appendix. If the latter, it was presumably due to implantation, but three and a half years seems a very long time for it to have taken to make its presence felt. In my experience secondary growths, which arise by implantation, are rapid in growth and are usually multiple and situated within a short distance of the primary lesion. I am inclined therefore to believe that this case is one of a second primary malignant growth.

I am indebted to Dr. Claridge, Pathologist to the Norfolk and Norwich Hospital, for preparing and reporting on the microscopical sections, and to Dr. Hutchinson, of Lowestoft, for the excellent microphotographs.

ACUTE INTUSSUSCEPTION IN A FEMORAL HERNIAL SAC.

By CECIL P. G. WAKELEY, London.

Although intussusceptions in hernial sacs have been occasionally described, the condition is a rare one. The following case is interesting because the hernial sac was bilocular and the inner sac was of enormous dimensions. Mrs. A. H., age 81, was admitted to King's College Hospital on Dec. 11, 1923, with a very large strangulated femoral hernia on the right side. The patient had been operated upon at St. Thomas's Hospital for right femoral hernia five years previously. The hernia had recurred about a year after the operation, and had gradually become larger, but had never given rise to intestinal obstruction. The patient was quite well until the evening before admission to hospital, when, while walking upstairs, she was suddenly seized with pain in the right groin. She noticed that the rupture was hard and painful; her bowels had been well opened about three hours previous to the attack. The patient vomited three times during the night, and the pain became somewhat lessened. The next morning she was brought up to hospital and admitted.

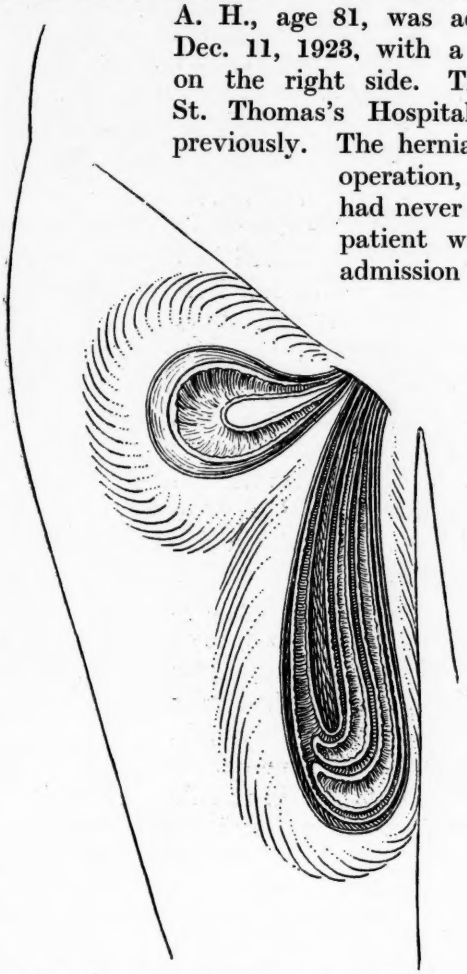

Fig. 415.—Intussusception in a bilocular femoral hernial sac.

On examination, a large bilobed swelling was seen below Poupart's ligament on the right side. The upper and outer portion of this swelling was resonant on percussion, and extended upwards towards the anterior superior iliac spine. The lower and inner portion of the swelling extended halfway down the thigh (*Fig.* 415), and was dull on percussion.

Operation was performed at once; a long curved incision was made over the larger swelling, and the hernial sac opened. It was found to contain an intussusception of the enteric variety, which was reduced with difficulty. This having been effected, another hernia was found in the upper part of the bilobed sac; this was reduced with ease. The large sac was excised, and its upper portion used to plug the enormous crural opening. A drainage tube was inserted into the thigh, as there was a large raw surface left after excision of the large hernial sac. The patient, in spite of her advanced age, stood the operation well; her bowels were opened every day after operation. However, bronchopneumonia became evident on the fourth day, as a result of which complication the patient unfortunately died. Autopsy was refused.

CARCINOMA OF SOLITARY KIDNEY WITH OTHER COMPLICATIONS.

By M. B. HANNAY, Paisley, and ROY F. YOUNG, Glasgow.

Mrs. J. W., age 52, was admitted to the Royal Alexandra Infirmary, Paisley, suffering from chronic intestinal obstruction of six weeks' duration, presumably due to a tumour in the hepatic region. Examination revealed abdominal distention with visible peristalsis. A large tumour of renal origin was felt in the right lumbar region. The diagnosis was made of malignant disease of the right kidney, with resulting obstruction of the ascending colon. Partial relief was obtained by enema.

The urine was acid, 1016, clear, with deposit of urates on standing; there was a trace of albumin. Microscopic examination showed leucocytes, a few red blood-corpuscles, calcium sulphate crystals, and a few hyaline, granular, and cellular casts.

Five days after admission, as the obstruction remained unchanged, operation was carried out with a view to relieve this. The obstruction was found to be caused by an enterolith in the transverse colon, behind which the bowel was hypertrophied and dilated. As the enterolith could not be passed on, it was removed through an incision in the bowel. At the time of operation some enlarged glands were felt in the mesentery.

Report on Enterolith (M. B. H.).—The specimen measured $1\frac{1}{2}$ by $1\frac{1}{8}$ inches in diameter, and weighed 24 grm. It cut easily, and was of the same consistency throughout, the cut surface having a yellowish-white appearance. There was no crystalline matter. Microscopically it consisted of amorphous débris, some of which was bile-stained, and there was much fatty matter, apparently in the form of soap. The general characters suggested that it consisted of dried fæcal matter.

The patient made an uninterrupted recovery from operation, but four days later 'menstruation' began, for the first time for six months. Nine days later there was free bleeding from the vagina. A catheter was passed into the bladder, and practically pure blood was drawn off. At the same time, however, it was noticed that blood was coming from the vagina also. The bleeding continued intermittently, and the patient gradually failed, and died twelve days later.

Post-mortem Examination.—The following is the report of the post-mortem examination (M. B. H.): Emaciation. Hypertrophy of heart (16 oz.), with some dilatation of the right ventricle. Old pleuritic adhesions, scattered on right side, general on left. Some calcareous tuberculous glands in the mesentery. A mucous polypus, attached to the cervix uteri, protrudes through the os, the diameter of the protruding part being about that of a shilling. There is hypertrophy of the right kidney, which is in its normal situation. The hepatic flexure crosses the lower pole of the kidney. The right ureter enters the bladder at its usual site. The left kidney and ureter are absent.

The kidney weighs just over $1\frac{3}{4}$ lb., and measures $7\frac{1}{2}$ by $4\frac{1}{4}$ by $2\frac{3}{4}$ inches in diameter. On bisection, the greater part of the lower pole is yellow in

colour and somewhat caseous in appearance, nodular on the surface, and contains some white fibrous-looking areas, as well as a few small hæmorrhagic patches. This yellow area is not encapsuled, and there are outlying small areas near it, as well as in the upper half, where a similar condition seems to be commencing at two points. The pelvis is hypertrophied, much dilated (about 1 inch in diameter), and filled with clot. There is a thickened area in its wall where it joins the ureter, presumably a secondary growth. The ureter is slightly hypertrophied, much dilated, and measures approximately $\frac{1}{2}$ inch in diameter.

FIG. 416.—Photograph of the kidney, on section. The tumour is at the lower pole.

Microscopically the yellow mass in the lower pole is a new growth composed of large alveoli lined by proliferating epithelial cells, and separated from one another by little more than thin-walled capillaries. There are areas of necrosis. The growth is not encapsuled, and shows a tendency to infiltrate the kidney substance at its margin. The general characters are those of a carcinoma.

COMMENTS.—According to Morris, as quoted by Thomson-Walker, the frequency with which unsymmetrical kidney occurs is about 1 in 2400 bodies, and the left kidney is more frequently absent than the right. I have been permitted to examine the post-mortem reports in the Royal Hospital for Sick Children, Glasgow, since 1915. In 1411 cases there was one case of unsymmetrical kidney (No. 387). In this case the left kidney was present and was larger than usual. On the right side there were neither kidney, ureter, nor renal vessels. Other developmental defects were present, namely imperforate anus and hypospadias. In the case reported here, there were no other developmental defects. Such solitary kidneys are said to be specially liable to be attacked by disease.

REVIEWS AND NOTICES OF BOOKS.

Exploration Clinique et Diagnostic Chirurgical. By FÉLIX LEJARS, Professor of Clinical Surgery at the Faculty of Medicine, Paris; Surgeon to l'Hôpital Saint-Antoine. Royal 8vo. Pp. 778, with 907 figures, 1923. Paris: Masson et Cie. Sewn, 50 francs; bound, 60 francs.

IT may safely be said that the reputation of the author of *Urgent Surgery* as a lucid and practical writer is fully maintained in this new work, which deals exhaustively with the various methods of regional examination with a view to arriving at a surgical diagnosis.

In his preface the author very rightly points out that, although at the present day the various physical, chemical, and bacteriological methods are of the greatest service, they have taken away nothing from the value of the traditional methods. The object of the book is thus a very commendable one, for it must be allowed that at the present time there is a great tendency to place an undue share of the responsibility of arriving at a surgical diagnosis upon laboratory methods, and the student is too apt to resort at once to these aids before, instead of after, he has exhausted all the ordinary methods of clinical examination. The work, which forms a very handsome volume, is profusely illustrated by original figures collected for the purpose during many years, and in the case of those showing methods of examination the author tells us that in each instance they were taken from patients actually suffering from the affection concerned.

The arrangement of the book is of course regional, and, although the attention of the reader is chiefly directed to the more common diseases and injuries in each part, the more rare conditions receive due notice. The style is conversational, and the reader is made to feel that the patient is actually before him.

The longest section deals with the abdomen, and by comparison the sixteen pages devoted to the cranium seems inadequate, and it is unfortunate that this section, which is the first in the book, should be the least satisfactory.

In a work dealing with all aspects of differential diagnosis it is inevitable that some omissions should occur and that some of the methods should be open to criticism. We can find no mention of actinomycosis, which certainly deserved consideration in dealing with affections of the neck and right iliac fossa.

In examining tumours of the breast, the author does not appear to us sufficiently to emphasize the importance of examination in the recumbent position, and, indeed, in nearly all the figures the patient is represented as erect. Clerical errors are extremely few, but McBurney becomes "Mac Burney" and Bryant's triangle is the "triangle de Bryan".

The book is a mine of practical information, and should prove a very worthy companion to the *Traité de Chirurgie d'Urgence*.

Elements of Surgical Diagnosis. By SIR ALFRED PEARCE GOULD. Sixth edition, revised by Eric Pearce Gould, M.D., M.Ch., F.R.C.S., Assistant Surgeon to the Middlesex Hospital; Surgeon to the Bolingbroke Hospital. Small 8vo. Pp. 739 + xvi, with 20 radiographic plates. 1923. London: Cassell & Co. Ltd. 12s. 6d. net.

THIS work, which was first published as long ago as 1884, is too well known to require any detailed review. The present edition is largely modelled on the original, but some re-arrangement and much careful revision has been carried out, while its usefulness has been enhanced by the insertion of some fifteen new radiographic illustrations, most of them excellent.

If students ever read the Preface, their attention will be arrested by these words: "With the striking exception of the diagnostic use of X rays, the progress of surgery since this book was first published has done little to provide short cuts to the diagnosis of surgical affections, and accuracy and confidence in diagnosis are still to be attained only by methodical and complete examination." The manual is a sure guide to the attainment of this object, and the preliminary chapter on "Method in Diagnosis" is full of wisdom.

There are some few matters which merit adverse criticism, and it would be well if the author in a future edition would delete the ugly word 'hydro-sarcocele', or would give its meaning. Similarly it would be helpful if the word 'trismus' were defined at the commencement of the section dealing with the temporo-mandibular joint. In discussing the conditions that may be mistaken for abdominal tumours, the author has evidently forgotten the story of Commodore Trunnion's lady, or pseudocyesis would have been more specifically mentioned.

It is a pleasure to remark on the way in which the book has been turned out by the publishers, and the pleasure is enhanced by the information that it has been done in Great Britain. The paper, print, illustrations, and binding are alike excellent.

The Effects of Radium upon Living Tissues: with Special Reference to its use in the Treatment of Malignant Disease. By SIDNEY FORSDIKE, M.D., B.S., F.R.C.S., Surgeon to Out-patients, Hospital for Women, Soho Square. Demy 8vo. Pp. 72 + viii, with 42 illustrations. 1923. London: H. K. Lewis & Co. Ltd. 5s. net.

THIS monograph is the subject matter of an essay for which the author has received the Jacksonian Prize. Under the above ambitious title we find compressed a fairly complete summary of the present position of radium as a curative agent in malignant disease, and particularly in relation to carcinoma of the uterus. The author introduces the work with a brief reference to the discovery of radium, and its physical properties, devoting a few paragraphs to the bearing of the latter upon the practical part of the work.

The physical section of the book is necessarily very elementary in character, but it suffices to throw some light upon the reason for the changes which are recorded in the more critical analysis of the changes induced in normal and morbid tissues.

The record of the action of radium rays upon the normal tissues is given in a number of experiments upon the ovary of cats. This part of the work is painstaking and reliable; the author succeeds in demonstrating a good deal of what is already well known, but it loses none of its value on that account, since corroboration of these changes is always valuable. One fact stands out prominently: all of the tissues examined showed changes due to the action of the radium, and in no part of the work does it show definitely that a specific selective action exists for any particular tissue.

A careful description of the technique, both in regard to the normal tissues and to carcinoma, is worthy of commendation as a concise and straightforward description of a technique which might be regarded as a standard for other workers.

Next follows a detailed summary of the treatment of fifty cases of carcinoma of the cervix uteri. Three of these were regarded as operable, forty-seven as inoperable. One of the operable cases died; the other two were alive eighteen months after the treatment; clinically they were free from the disease. The author wisely refrains from any statement of value in these cases.

Forty-seven inoperable cases: "All of these cases were too advanced for operation, many of them being within measurable distance of the termination of life; nevertheless, where there was any prospect of relieving pain, hæmorrhage, or offensive discharge, they were irradiated." From the point of view of palliation he succeeds in showing how effective radium can be when a good technique is followed. Discharges ceased and ulcerated surfaces healed, and the patients, for a time at least, were made more comfortable.

Dr. Forsdike is thoroughly conservative in his statement of the value of radium and X rays in the treatment of carcinoma, though he says that in rodent ulcer and

in sarcoma radium has succeeded in curing these conditions without a peradventure. This statement is open to question; a great deal depends upon what is regarded as a cure. In relation to carcinoma, he states that for late cases of cancer there is no comparison with any other treatment known. The claim is advanced that in 80 to 85 per cent of cases the symptoms are relieved with the minimum amount of invalidism, and that the patient is enabled to pursue her daily round without inconvenience to herself and without being a nuisance to others. This is obviously an optimistic view to take of the value of radium, particularly as many of his cases were admittedly not only in an advanced condition, but also complicated by sepsis. Dr. Forsdike also omits to state for how long his cases were enabled to pursue an ordinary daily course of life.

He concludes his summary by the pertinent question, Are we to continue to treat only inoperable cases? Dr. Forsdike is competent to answer the question; he has the knowledge of radium and its effects, he knows the results he has obtained, and he is a competent gynæcologist. Does he recommend operation or radium for the early cure of cervical carcinoma?

The book is well illustrated by half-tone reproductions of a large number of sections from normal tissues and from the series of cases of carcinoma in which the treatment by radium was carried out. It is recommended as a reliable guide for those wishing to try radium in suitable cases, and it should be useful to operating gynæcologists, if only for the service it renders in pointing out that radium is undoubtedly a valuable adjunct to the better-known methods of treatment, and one which offers a measure of relief to those patients who are beyond the reach of surgery.

The Diagnosis and Treatment of Acute Abdominal Diseases. By JOSEPH E. ADAMS, M.B., M.S., F.R.C.S., Surgeon to St. Thomas's Hospital. Second edition. Demy 8vo. Pp. 558 + x, with 46 illustrations. 1923. London: Baillière, Tindall & Cox. 16s. net.

WE consider this book a just presentation of the subject which cannot fail to be of service to those who consult it. There are sixteen chapters. The first gives a useful résumé of the main features of the surgical anatomy of the abdomen; the second treats of the method of investigating acute abdominal diseases; the third deals with the details of the technique of laparotomy; whilst the remainder of the book is devoted to the various groups of diseases, for the most part grouped anatomically. The last chapter is a most useful one, dealing with diseases which may simulate abdominal lesions. We are in accord with the author when he states: "If after a complete investigation of the case there is any real doubt as to whether to open the abdomen or not, explore." The inclusion of a special chapter dealing with the general post-operative complications is worthy of the author's consideration.

In a subject which is so extensive it is inevitable that we should find some points of difference. We are not "entirely opposed to exploratory puncture as an aid to the diagnosis of subphrenic abscess", though we recognize that such a method has its limitations and even dangers. In dealing with the subject of acute appendicitis without peritonitis, the remark is made that "rigidity is always present in some part of the right iliac fossa in the acute stage of the disease"; we can only comment that frequently there is no trace of rigidity demonstrable at the time of examination, and with a pelvic appendix it is the rule not to have any rigidity unless there be peritonitis.

Under the heading "Constitutional signs of obstruction" the author begins by stating, "The face is pallid and shrunken, the expression anxious, the complexion muddy". These are surely late symptoms which it is perhaps misleading to indicate as usual in the stage at which we all like to see such cases.

In a book which has so recently been revised, we should have liked to see some reference to Barnard's classical account of the course of intestinal obstruction by a gall-stone, and to Macartney and Fraser's recent work on pneumococcal peritonitis.

We are glad to see that the author recommends the division of Poupart's ligament in some cases of strangulated femoral hernia, and consider that his advice to use scissors instead of a hernia-knife is good.

Orthopædic Surgery. By ROYAL WHITMAN, M.D., M.R.C.S., F.A.C.S., Surgeon to the Hospital for Ruptured and Crippled, etc. Seventh edition, revised. Pp. 993 + xii, with 877 illustrations. 1923. London: Henry Kimpton. 42s. net.

DR. ROYAL WHITMAN'S *Orthopædic Surgery* remains, in spite of recent rivals, the most complete text-book on the subject, valuable alike to student, practitioner, and specialist. The best section of the book is that part which deals with tuberculous diseases of bones and joints, in particular the clinical account of the symptomatology and diagnosis of these conditions. In this section the accounts are so full and so accurate that they deserve to be studied by all practising surgeons, and they certainly form a most valuable text for a student to read. There is little that is new in this section, and perhaps some of the descriptions of mechanical methods might at the present time be omitted; but the whole account of tuberculous diseases is so complete and up to date, and also so fair in its discussion of different methods, that it would be difficult to find its equal in any other volume.

In the other sections the author's own work and methods naturally appear more prominently than do those of other surgeons, but even here there is on the whole a very fairly complete discussion of methods of all sorts. The only criticism that can be made is that perhaps physical methods of treatment, as apart from operative and mechanical, are too briefly described, and are given less prominence in orthopædic treatment than they deserve at the present time.

The principles of re-education of muscles and of posture are too little insisted upon, and such exercise treatment as is described, for example, under scoliosis, would be considered very old-fashioned by most present-day authorities on the subject. The set of dumb-bell exercises for scoliosis is still included, and Teschner's opinion is given that in the treatment of this deformity a general strengthening of the whole muscular system is indicated. It is to be feared that treatment on these lines too often results simply in a fixation of the existing deformity without correction.

The section at the end on collateral orthopædic surgery is in its present form rather diffuse, and the selection of items for description, and their order, are irregular. Possibly in some future edition the author may feel inclined to incorporate much of this work, which includes a very large and important section of orthopædic surgery, in the rest of the volume, putting each item in its proper place. In fact, although the matter of the book is excellent, the general plan upon which it is arranged is open to criticism. It gives the impression that a book written now some years ago has been revised from time to time by addition and substitution without any real attempt to rearrange matter in accordance with modern ideas and methods. The printing and illustrations remain up to the original high standard.

Le Sympathique Cervico-thoracique. By Prof. THOMAS JONNESCO. Large post 8vo. Pp. 92, with 34 figures and 10 plates in colour, and black and white. 1923. Paris: Masson et Cie. Fr. 42.

IN this monograph Professor Jonnesco records the work of twenty-five years upon the surgery of the cervical sympathetic. It is divided into three main sections, the first dealing with anatomy and physiology, the second with surgical technique, and the third with the clinical aspects of the subject. It is well illustrated, and contains a useful bibliography.

The operation described entails the removal of the whole cervical sympathetic chain. The early operations of Jaboulay for exophthalmic goitre (1896) and his own for epilepsy (1896) were, he holds, unsuccessful because they were too limited, and in his opinion a successful operation must include the inferior ganglion and with it, necessarily, the first thoracic ganglion. A bilateral operation has been carried out in some cases. The serious results recorded by physiologists as following sympathetic resection in animals do not occur in man. The operation is carried out under high spinal anæsthesia, for which a mixture containing caffeine, benzoate of soda, and stovaine is employed.

The conditions which Jonnesco has treated by 'sympathectomy' are exophthalmic goitre, epilepsy, migraine, trigeminal neuralgia, angina pectoris, and glaucoma.

Fifty cases of exophthalmic goitre, so treated, are quoted in some detail. There were but four deaths immediately following the operation. Of the 46 surviving patients, 8 who were followed for periods of from nine to twenty-four years were completely cured, whilst in the remainder the immediate benefit was very great. So enthusiastic is Jonnesco with regard to the results that he writes: "Total bilateral resection of the cervico-thoracic sympathetic is the only rational operation in the treatment of exophthalmic goitre."

For epilepsy the operation was done in 130 cases, with one death. Twelve patients were 'cured', and amongst these there were two who were followed for twenty-three and twenty-five years respectively, during which time no fit had occurred, although the epilepsy had existed, previously to the operation, in the one case for four years and in the other for three years.

As regards angina pectoris, the pain of which is ascribed to the sudden hypertension of the aorta or left ventricle, and is said to be conducted by the sympathetic by way of the stellate ganglion, 6 patients have been operated upon, with 2 deaths. The cases are related in detail, and the results appear to have been very striking, one patient being well seven years later.

The results obtained in migraine, trigeminal neuralgia, and glaucoma do not appear to be such as to encourage the employment of Jonnesco's operation for those conditions. It would seem, however, that as regards exophthalmic goitre and angina pectoris Jonnesco's claims are sufficiently well established to deserve the careful attention of those who are interested in the treatment of those conditions.

The Student's Handbook of Surgical Operations. By Sir Frederick Treves, Bart., G.C.V.O., C.B., LL.D., F.R.C.S., and Jonathan Hutchinson, F.R.C.S., Consulting Surgeon to the London Hospital, Examiner in Surgery, Glasgow Royal University. Fourth edition, enlarged. Pp. 552 + ix, with 167 illustrations. 1924. London: Cassell & Co. Ltd. 10s. 6d. net.

This well-known handbook has been somewhat enlarged and altered since the last edition. It still remains chiefly a guide to operations on the dead body, and the amount of space given to a description of ligature of arteries and amputations is quite out of proportion to the practical value of these operations. The claim which is made in the preface to include modern operations of practical importance is not fully borne out in the text. For example, while the preface distinctly states that operations for displaced semilunar cartilages have been described, a careful search in the index and text fails to discover such description.

Le Cancer Thyroïdien. By Léon Bérard and Chas. Dunet. Royal 8vo. Pp. 585, with 149 illustrations and 2 coloured plates. 1924. Paris: Doin. Fr. 40.

This is one of a series of monographs on cancer published under the direction of Professors Hartmann and Bérard. Volumes on cancer of the intestine, kidney, and rectum have already appeared.

The book is an excellent one, and a model of what a surgical monograph should be. It is the most complete work on the subject that we have yet seen. It has been written by two Lyons professors who have worked for many years in a district where goitre is extremely common. They have consequently had unrivalled opportunities for the study of their subject. Their large experience, tempered with sound judgement, is reflected in almost every page of the work.

Beginning with a full, but necessarily condensed, historical survey, the authors proceed to give an excellent summary of the embryology of the thyroid. Then follow chapters on the anatomy, histology, and physiology of the gland, together with a brief account of thyroid cancer in the lower animals.

After a short account of the etiology and distribution of thyroid cancer, the authors deal fully with pathological anatomy, both macroscopic and microscopic. The difficulties of a correct classification of malignant tumours of the thyroid

are pointed out, and reference is made to the excellent work of Wölfler and of Langhans, the eminent professor of Berne, and others to whom all workers in this field of pathology are so much indebted. Modern classification of thyroid tumours is based upon the separation of the thyroid apparatus into its constituent elements, as described in the chapters on embryology and anatomy (thyroid proper, parathyroid, post-branchial, etc.). They rightly point out that many, perhaps most, of the tumours hitherto described as sarcomas should more properly be classed as carcinomas. The puzzling 'mixed' tumours, the rare squamous-celled carcinomas, and others are ably and fully dealt with. The existence of the oft-described 'benign metastatic goitre' is, rightly we think, treated with scorn, such tumours being always malignant. A brief chapter deals with the difficult and little understood subject of the physio-pathology and biochemistry of thyroid cancer.

We are now halfway through the book. The second half deals with the clinical aspects of the subject. An excellent and lengthy chapter is devoted to the symptoms of the classical form of thyroid cancer, including those of sarcoma. Then follow short but good chapters on acute cancer, ligneous cancer, latent cancer, and cancer of aberrant thyroids. The difference between ligneous cancer and ligneous thyroiditis, so often confused with it, is fully discussed, and a somewhat amusing account is given (pp. 412–15) of the great discussion on this subject at the Société de Chirurgie of Paris in 1901.

The next chapter deals at some length with the difficult subject of diagnosis. All who have had much practical experience will agree with the authors that we have at present no means of making an accurate and *certain* diagnosis of malignant disease of the thyroid, in its early stage, that is, while it is still confined within the glandular capsule, at that stage at which alone radical surgical treatment offers much hope of success.

The last chapter is devoted to treatment. The indications and contra-indications for radical treatment are discussed temperately and wisely. Detailed instructions for the performance of the various operations are given. Stress is laid upon the dangers and complications which may accompany or follow such operations. The limitations which the prudent surgeon should set himself in this distressing field of surgery are well described. The various palliative operations which are so often called for are well discussed. The difficulties, dangers, and frequently distressing results of tracheotomy are portrayed by master hands who know the truth of the pictures they have been painting.

The only weak point that we can find in the book, after a very critical examination of it, lies in the illustrations, many of which are exceedingly poor. This is due partly, no doubt, to the quality of the paper on which they are printed, but not wholly. The worst are those which deal with macroscopic pathological anatomy. *Figs.* 30, 37, 38, 41, 43, for instance, show practically nothing, and the book would be better without them. The representations of microscopic sections are much better, and many of the photographs of patients are as good as can be expected in a work which is produced at so moderate a price. There is, unfortunately, no index.

We notice a good many misprints, such as Hugues for Hughes (p. 15), keste for Reste (p. 32), paratyhoïde for parathyroïde (p. 34), niveau for nouveau (p. 66), bronchiaux for branchiaux (p. 35). These are mostly quite trivial and do not detract from the general excellence of the book, on which we congratulate the authors most heartily.

Cleft Lip and Palate. By TRUMAN W. BROPHY, D.D.S., M.D., Emeritus Professor, Chicago College of Dental Surgery, etc. Royal 8vo. Pp. 344 + xxiv, with 466 illustrations and coloured plates. 1924. London: H. Kimpton. 30s. net.

A BOOK on any special branch of operative surgery written by one who has had long and extensive experience of that branch is always worth careful study. This volume is mainly a reprint of the chapters on these subjects in the author's earlier work on oral surgery, published in 1915. Various additions, alterations, and improvements have been added to bring the book up to date, and it doubtless represents Dr. Brophy's latest views on the whole subject.

In the first page of the preface, referring to the surgical treatment of cleft lip and palate, the author states boldly "that the American and European medical colleges, even of the greatest repute, give little or no information to their students upon this subject" (the surgical treatment of cleft lip and palate). We are of the opinion that this sweeping accusation is scarcely justified, at least as far as British Schools are concerned; nor does our experience of American and Continental Schools lead us to think that they merit this reproach.

The volume is divided into six chapters of very unequal length. The first (comprising about one quarter of the whole) deals with hare lip, or, as the author prefers to name it, 'cleft lip'. After a short description of the various forms of hare lip, illustrated by photographs, he gives a careful, and on the whole a good, description of the ordinary operations for this deformity, rightly laying stress on various details of importance. He states, however, that he has "abandoned the use of clamps and relies upon suitably formed mosquito forceps" to prevent hæmorrhage. He says nothing about using sponge pressure to check the free oozing which occurs in these operations and which cannot, in our opinion, be satisfactorily stopped by forceps alone. We are not surprised therefore to find that "hæmorrhage may be alarming, and imperil the life of the patient". We doubt whether the "aromatic spirits of ammonia . . . which should be always at hand to resuscitate the patient", or adrenalin chloride "for the suppression of capillary hæmorrhage" (p. 17), which the author recommends, are as valuable as lip clamps at the corners of the mouth, and sponge pressure, the use of which the author either condemns or does not mention. Herein may lie the explanation of what we can only call the high mortality, in Dr. Brophy's hands, of this usually simple operation, as shown by the table on p. 65. By this table we find that his total mortality up to the end of 1921—the latest year for which any figures are given—is 22, 13, and 8 per cent, respectively for infants aged one, two, and three months.* For older children, and for adults up to 30 years and over, the mortality is shown to be much smaller. We are also glad to see that the figures for the years 1915 to 1921 are better than those for the previous years, the mortality for the first two months of life being only 17 and 7 per cent. The total mortality for the next three months works out at 4, 4, and 3 per cent respectively.

Dr. Brophy also tells us that his mortality after hare-lip operations is greater than that after palate operations; but gives the astonishing explanation (p. 66) "that the lip operation is made when the child is older and more susceptible to depression".

The author gives a good description of the methods commonly employed for correcting the deformity of the nose usually associated with hare lip. For the suture of the cleft lip he employs only horsehair, and uses a strong temporary silk suture to hold the parts together during the suturing of the cleft. He relieves tension on the coaptation sutures by means of the Logan traction bow, which he illustrates (*Figs.* 58 and 59) and which seems to be a useful device for the cases which need it.

The various steps of the operations are illustrated by a series of drawings, some of which (e.g., *Figs.* 62–71) are a little fanciful, as they so often are in text-books on this subject. The illustrations do not afford as much help to the surgeon about to operate on one of the more difficult cases so often met with in actual practice as they would have done had they been taken from photographs or accurate drawings of really difficult cases.

The most interesting part of the book is Chapter 2, occupying nearly 200 pages and dealing with cleft palate. He proceeds to develop his views on the anatomy of cleft palate, and states that "the bones are not, as a rule, defective in structure nor incomplete in development. There is only abnormal elevation of the palate and failure of union". With most of this statement we are in agreement. It is accepted by most surgeons, we think, that the two halves of the palate are present but that they have failed to coalesce normally. They remain separated. The

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* At one month, 146 operations, 33 deaths. At two months, 198 operations, 26 deaths. At three months, 231 operations, 19 deaths.

statement that there is an "abnormal elevation of the palate" at least at birth, we believe to be wholly incorrect, and we do not think that Dr. Brophy's assertions and illustrations in any way prove this point. Most of us who are familiar with cleft palates and have had opportunities of watching them for a year or two after birth know that at birth, when the cleft is relatively much wider than it is later, the palatine plates are nearly horizontal. It is only later, as the cleft narrows spontaneously and the alveolar ridges develop, that the palatine arch becomes higher: this heightening of the arch and relative narrowing of the cleft is well shown in *Fig.* 159 from one of the author's own patients, a boy with tripartite cleft palate, upon whom he performed the first operation at the age of four years. Advantage is taken of these facts by those who advocate the performance of operation on the hard palate—as most surgeons in this country do—at a later period than does Brophy ("within three months after birth", p. 126).

The author's advocacy of a wiring operation in early infancy to bring together the separated bones is theoretically good. But what British surgeons (and we think many American also) wish to know is, whether this operation is worth doing: whether the advantage of bringing the edges of the cleft somewhat nearer together (for in most cases they cannot be brought into actual apposition) outweighs the undoubted severity and danger of the operation. Dr. Brophy wholly fails to convince us that it does.

Dr. Brophy assures us (p. 256) that his mortality after cleft-palate operations "has been extremely low". The greater number of patients who have died have "succumbed to gastro-enteritis. The operation has apparently not had anything to do with the death. It is possible that the operation may have been a contributing factor in some". Apparently it does not occur to him that the retention for several weeks within the mouth and jaws of an infant, of thick lead plates and stout silver wires, may lead to oral sepsis, and that this may be the cause of the gastro-enteritis of which his patients die.

Referring to cleft-palate operation, Dr. Brophy boldly states in the footnote on p. 126: "I am glad to state that the objections which were formerly made to operating on young infants no longer prevail, and that our more progressive surgeons advocate and practise early operations". If by "early" operations Dr. Brophy means operations within the period recommended by him, namely, within three months of birth, it is a great pity that these "progressive surgeons" do not come forward and publish series of consecutive cases, stating exactly the age of each patient, the nature of the cleft and the actual result obtained as regards the condition of the palate when last seen, and, if possible, the subsequent speech of the patient.

Finally, there is an excellent bibliography of 19 pages. This affords well-merited testimony to Dr. Brophy's untiring energy and enthusiasm for his views. We find that he has published no fewer than 26 communications on the subject, rather more than half of them to dental congresses, journals, or societies. There are both Subject and Author indexes.

The book is well got up and profusely illustrated, many of the illustrations being good. It will doubtless impress those who have no practical experience of the subjects with which it deals, and for whom, we presume, the book is primarily intended. The surgeon already experienced in this branch of surgery will read the book with interest, and perhaps with some amusement, for it is picturesquely written. Here and there he will doubtless pick up some point which will be useful to him in his practice, but we do not think that he will follow implicitly all the advice he finds therein.

A Text-Book of Minor Surgery. By EDWARD MILTON FOOTE, M.D., New York. Large 8vo. Fifth edition. Pp. 845, with over 480 illustrations. 1923. New York and Londor: D. Appleton & Co. 35s. net.

THE fact that this work has reached its fifth edition proves that it supplies a want, but a comparison with the last edition which appeared in 1919 leaves a feeling of disappointment that the book has not been brought more thoroughly up to date. It is true that some additions have been made, amounting in all to fourteen

pages, but the bulk of the volume, except for some rearrangement, remains almost unchanged, and the intention of the author expressed in the preface "that all its chapters may be in harmony with the new ideas" can hardly be regarded as accomplished. Many subjects which cannot reasonably be regarded as belonging to the domain of minor surgery are included, and by a judicious removal of these much space might be saved without impairing the practical use of the book.

Among the subjects which first find a place in this edition are the Carrel-Dakin treatment of wounds and the paraffin treatment of burns. A full description is also given of the treatment of varicose veins by the injection of a solution containing carbolic acid and other ingredients. The author seems satisfied with the results, but it is probable that most surgeons will hesitate to adopt such a method, especially when told that it is not necessary for the patient to go to bed and that the injection may be made in the doctor's office. Surely disaster would follow the wide adoption of such a proceeding.

In a work on minor surgery the reader naturally looks for accurate and detailed descriptions of the methods recommended, and reference must be made to various subjects which, together with others, the author might well consider when undertaking another revision. In speaking of retropharyngeal abscess it is stated that the abscess may be opened in the neck *in front of* the sternomastoid. No mention appears to be made of the bronchoscope in the removal of foreign bodies from the air-passages. In the treatment of a malignant tumour of the testicle (which incidentally is hardly a minor surgical procedure) it is advised to remove the organ together with the cord and *inguinal glands.* In the operation for hydrocele the sac is opened, and after removing part of the tunica the edges are sutured to the skin of the scrotal incision, the cavity is loosely packed with gauze and allowed to heal by granulation. Does the author really adopt this method? Does he actually allow a patient to walk home after an operation for varicocele? And does he really operate on an infant with a simple hare-lip without an anæsthetic?

No mention can be found of ischæmic contraction in fractures of the upper limb, or of the risk of tetanus in accidental wounds. Although reference is made to other agents, cocaine is very constantly recommended as a local anæsthetic, and it may be doubted whether this drug should even be mentioned in discussing spinal anæsthesia. Such blemishes, and there are many others, are the more striking because of the general standard of the work, and they should be corrected in the preparation of the next edition.

Two Lectures on Gastric and Duodenal Ulcer: A Record of Ten Years' Experience. By Sir Berkeley Moynihan. Royal 8vo. Pp. 48, illustrated. 1923. Bristol: John Wright & Sons Ltd. 2s. 6d. net.

Although previously published in medical journals, these lectures are so valuable that it is a pleasure to see them in more permanent form. There is a charm about the addresses of Sir Berkeley Moynihan which makes listening to them a pleasure. This charm remains in the written sentences, and in addition they are a lucid statement of the faith and experience of perhaps the greatest authority on these particular subjects, and as such will become classical.

Handbook of Anæsthetics. By J. Stuart Ross, M.B., Ch.B., F.R.C.S.E., Lecturer in Practical Anæsthetics, University of Edinburgh; Hon. Anæsthetist, Edinburgh Dental School. Second Edition. Crown 8vo. Pp. 328 + xvi, with 71 illustrations. Edinburgh: E. & S. Livingstone. 8s. net.

In producing a second edition of this valuable little book, the author has succeeded in keeping its size well within the scope of every student, although he has added enough new material to bring it quite abreast of the times. The work still maintains, as its outstanding feature, a thoroughly practical clinical tone, with just sufficient academical material to explain the author's attitude in reference to certain controversial problems. Among the additions contained in this edition readers will welcome the references to Haldane's work on respiration. The sections dealing with the open method of administering ether and the details of nitrous oxide anæsthesia are

especially valuable. In the former, stress is laid upon the importance of keeping the concentration of ether vapour within definite limits in order to obviate the risk of pulmonary complications, and the view is expressed that it is wiser to amplify the strength of the anæsthetic by the addition of small quantities of chloroform than by increasing the dose of ether. Under nitrous oxide there is an unusually clear account of the phenomena peculiar to the induction and development of anæsthesia, and the whole section is very practical, as one might expect considering the large amount of pioneer work done by the author in this connection.

There is a clerical error which we feel bound to draw attention to on page 288 where the dose of tropacocaine for spinal anæsthesia is given as 0·7 instead of ·07 grm. Students of anæsthesia will find this book full of reliable information put concisely but not too dogmatically.

Saint Bartholomew's Hospital Reports. Vol. LV. Edited by F. W. Andrews, W. McAdam Eccles, G. E. Gask, W. D. Harmer, H. Thursfield, and H. Williams. 4to. Pp. 180. 1922. London: John Murray. 10s. 6d.

THE reviewer's appreciation of this number is in a sense painful, in that it contains a memoriam notice of the late Dr. Bainbridge, F.R.S., whose work he was privileged to see many years ago when Dr. Bainbridge was doing research work at University College. His breadth of mental outlook and his highly developed critical sense fitted him so unusually for research as to make his loss the greater. It was also peculiarly interesting to read in the Reports of another hospital the life of the greatest of Guy's surgeons, Sir Astley Cooper. Mr. Geoffrey Keynes has carefully gone through the records at his disposal, and in sketching a very readable biography gives an interesting and clear-cut account of the causes of Sir Astley Cooper's success, and indicates the qualities of mind and character which made his rise to the head of the profession so phenomenally rapid. The volume also contains a fifth series of ninety-five cases of intussusception carefully analysed and brought up to date by Mr. W. E. Wilson. Not the least interesting features of this number are the "Descriptions of Specimens added to the Museum during the year 1921", which are models not only for the uniform manner in which each specimen is described, but also for the aptness of the terms used, and the conciseness of the diction.

Saint Bartholomew's Hospital Reports. Vol. LVI, Part 2. 4to. Pp. 198. 1923. London: John Murray.

MUCH of this volume is devoted to the various aspects of syphilis. So old and conservative an institution is to be congratulated in that it invites authorities such as Mr. J. Adams to lecture within its walls. His paper on "Antenatal Syphilis", well summarizes all that is known of the subject at the present time. Of the other articles, that on "Diverticula of the Bladder" by Mr. W. Girling Ball discusses very thoroughly the different theories which have been put forward to account for these lesions, and is well illustrated by some unusually well-executed drawings of specimens.

Essentials of Oral Surgery. By VILRAY PAPIN BLAIR, A.M., M.D., F.A.C.S., Professor of Oral Surgery in the Washington University Dental School; and ROBERT HENRY IVY, M.D., D.D.S., F.A.C.S., Professor of Maxillo-facial Surgery in the Graduate School of Medicine. Royal 8vo. Pp. 526, with 335 illustrations. 1923. London: Henry Kimpton. 32s. net.

THIS is a text-book containing the subject matter taught to their undergraduate students by the authors, who explain that they have laid stress on the *recognition* of surgical conditions, but have not thought it necessary to describe major operations in detail.

Keeping in mind the chief object of the book, and passing the main chapters in review, one notes instruction in Chapter 1 which should be useful to higher dental students, and the consideration of points of anatomical survey as applied to practical work is well conducted. Both the chapters on inflammation and on special infections

contain sound surgical teaching. The classification of tumours is useful, and also the chapter on hæmorrhage and shock, except that the injection of serum should not be advocated without warning students of the possibility of anaphylaxis.

Dealing with the treatment of X-ray burns, the authors say: "The best form of treatment for severe burns seems to be the removal of necrotic tissue and granulations, and the application of thick grafts or flaps transferred from neighbouring healthy tissue. According to F. C. Wood, even if such flap grafts slough, they sometimes leave the tissue in such a healthy condition that Thiersch grafts will then grow satisfactorily". Though it is perfectly correct to advocate grafting, some stress might have been laid on the fact that the excision is the more important part of the operation, as, after it, even without subsequent grafting, the pain and general character of the burn will change, and it will heal better than if it had been left alone.

The chapter on fractures contains some illuminating discussion, particularly on fractures of the jaw—obviously a subject on which the authors have thought a great deal—and on the whole the methods advocated for splinting the fracture are to be recommended.

The treatment advised for peri-apical affections is not generally accepted in this country. It does not appear necessary in a book of this sort to deal with the extraction of teeth, but more should have been said on the common condition of the impacted third molar. In diseases of the maxillary sinus, the authors touch on too many subjects, giving a little knowledge which would prove dangerous to the student. This is particularly the case in the diagnosis, which would not pass muster in the clinic of a throat and nose surgeon, though the advice for treatment is good. Tumours of mouth and jaws are well dealt with, and the description of the congenital clefts is very good. The operative treatment is more difficult to criticize, because it is, to a certain extent, condensed and, in fact, is afforded rather meagre space for such a large subject; but it appears a fairly sound epitome of the usually adopted principles. For orthodontia, the authors' operation is given—a sound though severe treatment. There are some valuable pages on diseases of the mandibular joints and resection of the condyle, and on the affections of the tongue.

In the last chapter the use of local anæsthesia is well worked out, but the methods of general anæsthesia as described here are far inferior to those practised in this country; very little is made of the intratracheal method, and it is stated that considerable practice in the introducing of the tube is required, which is, of course, incorrect.

On the whole, then, the book contains sound instruction from two good surgical teachers, and is also interesting as a record of personal practice. As a book of reference it will very often supply what is wanted, but it will also often disappoint because of lack of detail. There is a certain amount of padding—preparation of the operation fields and so on—with explanations in detail of things the student should know before he ever reads a book. Some of the radiograms are very bad—the one on page 153 for instance, which shows nothing at all, and has to be explained by means of arrows.

Lateral Curvature of the Spine, and Round Shoulders. By ROBERT W. LOVETT, M.D., Sc.D., Professor of Orthopædic Surgery, Harvard University. Fourth edition, revised. Pp. 218 + xii, with 172 illustrations. 1923. London: H. K. Lewis & Co. Ltd. 12s. 6d. net.

DR. LOVETT'S book remains the most comprehensive account of scoliosis at present published in England or America. It is, however, in some points still incomplete, and the new edition cannot be considered as quite up to date. The most striking omission is the absence of any account of the bearing of recent muscle physiology upon the development of scoliosis and kyphosis; the postural activity of muscles is not mentioned at all. Dr. Lovett expresses the view that postural curvatures of the spine are not likely to be cured spontaneously, but only as the result of suitable remedial gymnastics. In this he takes a view which it is difficult to support if observations made in schools are borne in mind, for we find that 25 per cent of school children show a postural curvature, and this percentage steadily diminishes as adult

life is reached without any treatment whatever. In fact, Dr. Lovett seems to ascribe too little to the normal development of a sense of balance in the cure of scoliosis.

In the very excellent short set of exercises too much insistence is made upon the necessity for fixing the pelvis as a preliminary to many of the movements. Here, again, there is a failure to realize the importance of developing a sense of balance, the artificial fixing of the pelvis assisting this sense so greatly as to interfere with the educational value of the exercises.

Dr. Lovett rightly insists upon the difference between postural and structural curvatures, or, as he calls them, false and true scoliosis, stating that the latter is a bone problem. An excellent account is given of the various methods of forcible correction and the use of plaster-of-Paris jackets; Abott's method is briefly described, and the findings of the Committee of the American Orthopædic Association upon the value of this method are given. The investigations of this committee have relegated this method to its proper position in treatment, i.e., as a method which has its uses but which is not the infallible cure that it was claimed to be by its author. There is a complete omission of all descriptions of the uses of recumbent splints, such as plaster-of-Paris beds, and of correction by pressure in them. In spite of these various omissions the book remains an invaluable one for the orthopædic surgeon and medical gymnast, and should be studied by all members of these two professions who are concerned in the treatment of spinal curvatures.

Radiography and Radiotherapeutics. By ROBERT KNOX, M.D., C.M., M.R.C.S., L.R.C.P., Consulting Radiologist, Great Northern Central Hospital, London. Part I: Radiography. Fourth edition. Super royal 8vo. Pp. 448 + xxv, with 93 plates and 337 illustrations. 1923. London: A. & C. Black Ltd. 40s. net.

THE fourth edition of Dr. Knox's well-known book on radiography has been brought up to date and considerably enlarged, especially as regards the chapters dealing with the examination of the gall-bladder and urinary tract. This edition undoubtedly maintains the high reputation already acquired by the work, which remains the most comprehensive and authoritative treatise on the subject in this country.

The general arrangement of the book is excellent, and a large amount of detail is included in a comparatively small compass. The essentials of the physics of the subject are fully dealt with, and the student and general practitioner alike will find no difficulty in gaining a clear understanding from these chapters of the production and use of X rays for diagnostic purposes. The various types of apparatus employed in radiography are carefully described, and many points of practical value are emphasized. The chapters on diagnosis are copiously illustrated, and most of the plates are excellent, especially those dealing with the chest and gastro-intestinal tract.

The appendix contains several chapters giving useful hints on the differential diagnosis of renal and gall-bladder cases, also a description of the Lilienfeld tube and a chapter on the Potter-Bucky diaphragm, the use of which is now regarded as indispensable by most radiographers.

Dr. Knox is to be congratulated on the continued success of his book, the present edition of which bids fair to maintain its popularity.

A Handbook of Surgery. By GEORGE L. CHIENE, M.B., C.M., F.R.C.S.Ed., Surgeon, Edinburgh Royal Infirmary; Senior Lecturer and Examiner in Clinical Surgery, University of Edinburgh. Crown 8vo. Pp. 592 + xii, with 109 illustrations. 1923. Edinburgh: E. & S. Livingstone. 12s. 6d. net.

THIS small text-book was written with the object of providing a book for those who have not time to study larger volumes. An attempt is made to emphasize the more common and more important surgical conditions, and little space is given to the consideration of surgical rarities. It presumably represents the commonly accepted teaching in the Edinburgh school. The writing is clear and lucid, and a very great deal of information is compressed into a small compass. The illustrations, although numerous, are not perhaps as clear and diagrammatic as they might have been for a work of this kind.

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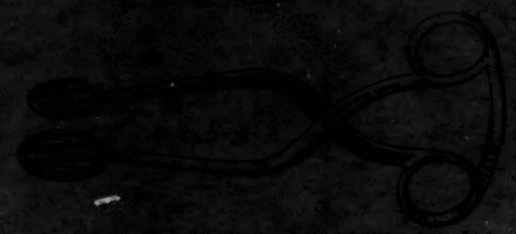

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